RNNP

TRENDS IN RISK LEVEL IN THE PETROLEUM ACTIVITY
SUMMARY REPORT 2016
THE NORWEGIAN CONTINENTAL SHELF

Preface

Trends in the risk level in the petroleum industry concern all parties involved in the industry, as well as the general public. It was therefore natural and important to establish an instrument to measure the impact of the industry's overall HSE work.

RNNP as a tool has developed considerably since its inception in 1999/2000 (first report published in 2001). This development has taken place through a multipartite collaboration, characterised by agreement on the prudence and rationality of the selected course of development in terms of creating a basis for a shared perception of the HSE level and its development in an industry perspective. The work has taken on an important position in the industry in that it contributes towards forming a shared understanding of the risk level. In 2010, we published the first RNNP report concerning acute spills to sea. The report is based on RNNP data combined with data from the Norwegian Oil and Gas Association's EPIM database (formerly Environmental Web - EW). Due to the data collection period in EPIM, the RNNP report on acute spills will not be published until autumn.

The petroleum industry has considerable HSE expertise. We have utilised this expertise by facilitating open processes and inviting contributions from key personnel from operating companies, helicopter operators, consultancies, research and teaching.

Objectivity and credibility are key for any qualified statements regarding safety and the working environment. We therefore depend on the parties having a shared understanding of the reasonableness of the methodology employed, and of the value created by the results. The parties' ownership of the process and the results is therefore important.

Many people have contributed to the execution, both internally and externally. It would take too long to list all the contributors, but I particularly want to mention the positive attitude we have encountered in our contact with the parties in connection with execution and further development of the work.

Stavanger, 27 April 2017

Finn Carlsen,
Director for Professional Competence, PSA

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1. Objective and limitations

1.1 Objective

The "Trends in risk level on the Norwegian Continental Shelf" project started in the year 2000. The Norwegian petroleum activities have gradually evolved from a developmental phase to a phase dominated by operation of petroleum facilities. There is now a strong focus on cost reductions in the industry. The player landscape is also changing, as more and more new players are being approved.

The industry has traditionally used a selection of indicators to illustrate safety trends in the petroleum activities. Indicators based on the frequency of lost-time incidents have been particularly widespread. It is generally accepted that this only covers a small part of the overall safety picture. In recent years, the industry has used more indicators to measure trends. For the parties in the industry, it is important to establish methods for measuring the impact of the industry's overall safety work.

In this report, the Petroleum Safety Authority Norway wishes to create profiles of the risk level based on sets of information and data from the activities, to allow the impact of the overall safety work in the activities to be measured.

1.2 Purpose

The objective of the work is to:

- Measure the impact of the industry's HSE work.
- Contribute to identifying areas that are critical for HSE and where the effort to identify causes must be prioritised in order to prevent undesirable incidents and accidents.
- Increase insight into potential causes of accidents and their relative significance for the risk profile, to provide better decision support for the industry and authorities concerning preventive safety and emergency preparedness planning.

The work may also contribute to identifying focus areas for amending regulations, as well as research and development.

1.3 Key limitations

In this report, the spotlight is on personal risk, which here includes major accidents and occupational accidents. Both qualitative and quantitative indicators are used.

The work is restricted to matters included in the PSA's area of authority as regards safety and the working environment. All passenger transport by helicopter is also included, in cooperation with the Civil Aviation Authority Norway and the helicopter operators on the Norwegian Continental Shelf (NCS). The following areas are covered:

- All production and mobile facilities on the NCS, including subsea facilities.
- Passenger transport by helicopter between the helicopter terminals and the facilities.
- Use of vessels within the safety zone around the facilities.

Onshore installations in the PSA's administrative area are included as of 1 January 2006. Data collection started from this date, since when separate reports have been published. Outcomes and analyses for onshore installations and the results from these installations are not included in this summary report. Since 2010, an annual report has been published with the spotlight on acute spills to sea from offshore petroleum activities. The next report concerning acute spills is expected during the autumn of 2017.

2. Conclusions

The PSA seeks to measure progress in safety and the working environment using a series of indicators. This work is also important for preventing acute pollution of the environment. The basis for the evaluation is the triangulation principle, i.e. assessing developments by measuring trends in risk levels in a variety of ways.

Trends are the main focus. It must be expected that some indicators, particularly within a limited area, will at times display large annual variations. The petroleum industry should therefore focus on the positive development of long-term trends, particularly in light of Parliament's goal for the Norwegian petroleum industry to be a world leader in HSE.

Underreporting of information concerning incidents and near-misses cannot be excluded. In RNNP, a lower threshold is consistently used in respect of severity/the potential for which information is included in the data for the indicators. One reason for this is to reduce the impact of any underreporting on the assumption that the degree of underreporting will be less for more serious incidents and near-misses. Although previous investigations have shown that underreporting has not changed the conclusions of the reports, it must always be taken into account that the type of information used in RNNP is subject to uncertainty.

Ideally, one should arrive at a summary conclusion on the basis of information from all the measurement instruments used. In practice, this is complicated, for example because the indicators reflect HSE conditions at levels that may be significantly different. This report particularly examines risk indicators associated with:

- Major accidents, including helicopter-related accidents
- Selected barriers associated with major accidents
- Serious personal injuries
- Changed risk conditions

Data for the indicators for noise, chemical working environment and ergonomic risk factors are not reported for 2016 due to weaknesses in these working environment indicators. We are developing alternative models for the working environment indicators. The Petroleum Safety Authority Norway will produce final proposals for RNNP working environment indicators in the spring of 2017.

Major accidents

The helicopter accident at Turøy on 29/4/2016 claimed 13 lives. The accident made its mark on the activities and shows with great clarity that petroleum activities entail a major accident risk.

In 2016, 11 hydrocarbon leaks exceeding 0.1 kg/s were recorded. This is the highest number recorded since 2011. The contribution to the total indicator in 2016 is among the highest in years without leaks exceeding 10 kg/s. The relatively high risk contribution in 2016 derives from six incidents in the category 1-10 kg/s, with one leak in the upper level at a rate of 8 kg/s.

14 well control incidents were recorded in 2016, 12 in the lowest risk category (level 3), one in the medium risk category (level 2) and one in the high severity category. All were linked to production drilling. There were no incidents in connection with exploration drilling in 2016. The number of well control incidents per 100 production wells was at a relatively high level in 2016 compared with the last five years and is the highest since 2010, but not significantly higher. The risk indicator for production drilling has been at a stable level for the last five years, but there was a large increase in 2016, primarily due to the well control incident with the highest level of severity.

Two ships on collision courses were recorded in 2016, a fall from 2015. Assessed against the number of facilities monitored from Sandsli, this was a significantly lower level than in the period 2006-2015. We can see that controlled sea areas around the facilities have had an impact for a number of years.

One incident concerning a large drifting object was recorded in 2016. A failure in the tow of a barge in the North Sea caused the barge to drift towards Gjøa. The standby vessel established a tow and manoeuvred the object out of the safety zone.

There were no collisions between facilities and field-related vessels (supply vessels) in 2016, only one incident during a removal, but with no risk of personal injury. There have been no serious collisions in the last five years.

In 2016, there were four incidents relating to structures and maritime systems. One of the incidents concerned a line failure on a mobile facility and three incidents concerned wave impacts on semi-submersible facilities.

No leaks from production facility risers or from pipelines were reported in 2016. In 2016, one incident of serious damage to a flexible riser was reported. There were no reported incidents of serious damage to subsea facilities within the safety zone in 2016.

There were two fires in 2016, one in a machine room on a mobile unit and one in the shaft of a fixed facility.

The other indicators reflecting near-misses with major accident potential show a stable level, with relatively minor changes from 2015 to 2016.

The total indicator reflecting the potential for loss of life if near-misses develop into actual incidents is a function of the number of registered incidents and their associated potential consequences. A historical risk indicator does not express risk, but may be used to assess trends in the parameters contributing to risk. A positive development in an underlying trend for indicators can provide an indication that we are achieving better control of the contributors to risk. Or, in other words, that risk management is improving.

The total indicator for 2016 is at an equivalent level to 2015. This level is higher than in 2013 and 2014, but the change is not significant compared with the period 2006-2015. Well control incidents are the largest contributor to the total indicator in 2016, and these in turn are dominated by a single incident. When this indicator includes a limited number ofincidents, the total indicator will be sensitive to individual incidents.

Helicopter risk constitutes a large share of the overall risk exposure to which employees on the NCS are subject. The purpose of the risk indicators used in this work is to capture the risk involved in the incidents included in the survey and to identify areas with improvement potential. Among other things, an expert group has been established under the auspices of RNNP to assess the risk associated with the most serious helicopter incidents. The expert group consists of personnel with pilot, technical, ATM and risk expertise.

In the period in which RNNP has collected helicopter-related data, the Turøy accident in 2016 is the only helicopter accident involving a fatality. The previous fatal helicopter accident on the NCS occurred on a flight to the Norne field in 1997. One consequence of the methodology used in RNNP is that actual accidents are handled in the same way as near-misses. Fatal accidents will affect any weighting used to assess the potential of future near-misses for causing loss of life. The Turøy accident will therefore be included in incident indicator 1 as an incident with no remaining barriers.

In the expert group's assessment of incidents for 2016, there were two incidents with no remaining barriers. One is the Turøy accident and the other is an incident during taxiing in which a helicopter rotor brushed and damaged a parked lorry at Stavanger Airport.

Barriers
The industry is increasingly focusing on indicators that are able to describe robustness in terms of withstanding incidents – so-called leading indicators. Barrier indicators are an example of these. The barrier indicators show that there are large differences in levels between the facilities. Over time, a positive trend has been observed for some of the barriers that have been above the industry standard in recent years:

- Riser ESDV closure tests show a fall from 2011 to 2014 and are relatively stable at the same level in 2015 and 2016.
- In 2016, riser ESDV leak tests and deluge valves were under the industry standard of 0.01.
- BDVs show a fall from 2012 to 2015 and are at around the same level in 2016.

DHSVs however have shown a rising trend from 2013 to 2016 and remain above the industry standard in 2016. Other barriers remain stable below applicable industry standards. This may mean that the focus in recent years on barrier management in the industry is also yielding results within this area.

Maintenance management data have been collected for more than five years. The data for the permanently fixed facilities show that there are few hours of backlog in preventive maintenance, but that a number of facilities have not performed HSE-critical preventive maintenance in accordance with defined deadlines.

Some facilities still have a considerable number of hours of corrective maintenance unperformed, but the number of hours is significantly reduced in some instances in 2016 compared with the preceding year. There is also a fall in the total outstanding HSE-critical corrective maintenance in 2016 (maintenance not performed in accordance with defined deadlines) compared with previous years.

The hours of preventive maintenance performed fell considerably in 2016 compared with recent years. Hours of corrective maintenance performed are also somewhat lower in 2016 than the preceding year, but the reduction is much less than for preventive maintenance.

The data for the mobile facilities show a certain increase for some facilities in terms of the number of tagged and classified pieces of equipment. The data show large variations in the backlog of preventive maintenance and in outstanding corrective maintenance per facility. This corresponds to what we have seen in recent years. We took this up with the participants last year and will follow it up further this year.

Personal injuries and accidents
There were no fatal accidents within the PSA's area of authority on the NCS in 2016, but on 29 April 2016, 13 people died when a Super Puma helicopter crashed while flying from Gullfaks B to Flesland. This accident is in the Civil Aviation Authority Norway's area of authority.

In 2016, 191 reportable personal injuries were registered on the NCS, 16 of which were classified as serious.

Over the long term, in the period from 2006 to 2016, there has been a downward trend in the frequency of serious personal injuries. However, there was an increase in the injury rate in 2014 and 2015. The injury rate in 2016 (0.46) is the lowest registered in this period. The frequency of serious personal injuries in 2016 is below the level expected compared with the preceding 10 years. The frequency of serious personal injuries on production facilities follows the same trend as for the entire NCS, but the value in 2016 is not significantly lower than in the previous 10 years. As of 2013, the injury rate on mobile facilities has shown a rising trend, but with a considerable fall in 2016. The value in 2016 is however not statistically significantly lower than the value in the preceding 10 years.

Changed risk conditions
There have been some changes in offshore activities linked to the psycho-social working environment and safety climate in this period of major change processes. A greater percentage of the employees on mobile facilities report high job demands and low job control and the combination of these, and-, on the production facilities, a greater percentage of the employees report low job control and a poorer safety climate. This may be viewed in the context of the ongoing change processes. The level of self-reported work accidents involving personal injury, health complaints and sickness absence was reasonably constant during the period.

However, the results show fairly clearly that employees who have experienced reorganisation and downsizing report higher risks of injury, sickness absence, health complaints and a poorer safety climate and psycho-social working environment compared with employees who have not reported such changes. The analyses also indicate that the higher risk of injury reported by those affected by downsizing and reorganisation in the industry as a whole may be related to a poorer safety climate and psycho-social working environment.

3. Work undertaken

The work in 2017 is a continuation of activities performed in 2000–2016; see previous reports on our website (www.ptil.no/rnnp). The most important elements in the work were:

- The work on analysing and evaluating data concerning defined hazard and accident situations has been continued, both on the facilities and for helicopter transport.
- Completed analysis of "Changed risk conditions".
- A considerable volume of empirical data on barriers against major accidents was collected and analysed in the same way as in the period 2003-2015.
- Indicators for noise, chemical working environment and ergonomics have not been continued.
- Data from onshore installations have been analysed and presented in a separate report.
- Data on acute spills to sea and potential spills to sea are undergoing analysis, and will be presented in a separate report.
- Examined relationships in the data.

3.1 Performance of the work

The work on this year's report began in January 2017. The following organisations and people participated:

• Petroleum Safety Authority Norway:	Responsible for execution and further development of the work
• Operating companies and shipowners:	Contribute data and information about activities on the facilities.
• The helicopter operators:	Contribute data and information about helicopter transport activities
• HSE specialist group: (selected specialists)	Evaluate the procedure, input data, viewpoints on the development, evaluate trends, propose conclusions
• Safety Forum: (multipartite)	Comment on the procedure, results and recommend further work
• Advisory group: (multipartite)	Multipartite RNNP advisory group that advises the Petroleum Safety Authority regarding further development of the work.

The following external parties have assisted the Petroleum Safety Authority with specific assignments:

- Terje Dammen, Jorunn Seljelid, Beate Riise Wagnild, Torleif Veen, Trine Holde, Marie H. Saltnes, Trond Stillaug Johansen, Asbjørn Gilberg, Kai Roger Jensen, Ragnar Aarø, Rolf Johan Bye, Nathaniel John Edwin and Olav Brautaset, Safetec
- Cecilie Aagestad, Tom Sterud, Tore Tynes, Eva Løvseth and Berit Bakke, STAMI
- The PSA's working group consists of: Øyvind Lauridsen, Mette Vintermyr, Tore Endresen, Arne Kvitrud, Narve Oma, Morten Langøy, Trond Sundby, Hilde Nilsen, Inger Danielsen, Elisabeth Lootz, Jon Erling Heggland, Sigvart Zachariassen, Brit Gullesen, Anne Sissel Graue, Anne Mette Eide, Hans Spilde, Semsudin Leto, Eivind Jåsund, Bente Hallan, Bjørnar Heide and Torleif Husebø.

The following people have contributed to the work on indicators for helicopter risk:

- Erling Munthe-Dahl, Norwegian Oil and Gas Association, represented by LFE
- Egil Bjelland, Morten Haugseng and Trond Arild Nilsen, CHC Helikopter Service
- Ole Morten Løge and Caspar Cappelen Smith, Bristow Norway AS

Numerous other people have also contributed to the work.

3.2 Use of risk indicators

Data have been collected for hazard and accident situations associated with major accidents, work accidents and working environment factors, specifically:

- Defined hazard and accident situations, with the following main categories:
    - Uncontrolled discharges of hydrocarbons, fires (i.e. process leaks, well incidents/shallow gas, riser leaks and other fires)
    - Construction-related incidents (i.e. structural damage, collisions and risk of collision)
- Test data associated with the performance of barriers against major accidents on the facilities, including data concerning well status and maintenance management
- Accidents and incidents in helicopter transport
- Occupational accidents
- Diving accidents
- Other hazard and accident situations with consequences of a lesser extent or significance for preparedness.

The term 'major accident' is used in many places in the reports. There are no unambiguous definitions of the term, but the following are often used, and coincide with the base definition employed in this report:

- A major accident is an accident (i.e. entails a loss) where at least three to five people may be exposed.
- A major accident is an accident caused by failure of one or more of the system's built-in safety and emergency preparedness barriers.

Viewed in light of the major accident definition in the Seveso II Directive and in the PSA's regulations, the definition used here is closer to a 'large accident'.

Data collection for the DFUs (defined hazard and accident conditions) related to major accidents is founded in part on existing databases in the Petroleum Safety Authority (CODAM, DDRS, etc.), but also to a significant degree on data collection carried out in cooperation with the operating companies and shipowners. All incident data have been quality-assured by, for example, checking them against the incident register and other databases in the Petroleum Safety Authority.

Tabell 1 shows an overview of the 20 DFUs, and which data sources have been used. The industry has used the same categories for registering data through databases such as Synergi.

3.3 Developments in the activity level

Figur 1 and Figur 2 show the developments over the period from 2000 to 2016 for production and exploration activities, of the parameters used for normalisation against the activity level (all figures are relative to the year 2000, which has been defined as 1.0). Appendix A to the main report (PSA, 2017a) presents the underlying data in detail.

Table 1 Overview of DFUs and data sources

DFU no.	*DFU description*	*Data sources*
1	Unignited hydrocarbon leak	Data collection*
2	Ignited hydrocarbon leak	Data collection*
3	Well incident/loss of well control	DDRS/CDRS + incident reports (PSA)
4	Fire/explosion in other areas, combustible liquid	Data collection*
5	Ship on collision course	Data collection*
6	Drifting object	Data collection*
7	Collision with field-related vessel/facility/shuttle tanker	CODAM (PSA)

DFU no.	*DFU description*	*Data sources*
8	Damage to platform structure/stability/anchoring/positioning fault	CODAM (PDA) + the industry
9	Leak from riser, pipeline and subsea production facility**	CODAM (PSA)
10	Damage to riser, pipeline and subsea production facility**	CODAM (PSA)
11	Evacuation***	Data collection*
12	Helicopter crash/emergency landing on/near facility	Data collection*
13	Man over board	Data collection*
14	Personal injury	PIP (PSA)
15	Work-related illness	Data collection*
16	Full loss of power	Data collection*
18	Diving accident	DSYS (PSA)
19	H_2S emission	Data collection*
20	Crane and lifting operations	Data collection*
21	Falling object	Data collection*

* Data collection is carried out in cooperation with the operating companies
** Also includes wellstream pipeline, loading buoy and loading hose where relevant.
*** These incidents are principally major-accident-related, but are not used in this way in the present work. Only incidents that have caused an actual evacuation (by lifeboat) are counted, i.e. not precautionary evacuations.

This is a fall in total working hours for production facilities of around 9% compared with the previous year. Working hours in production in 2016 are therefore at the lowest level since 2002. This is a marked reduction, and the total number of working hours in 2016 is around 9.2% below the average for the period 2000-2015. For mobile facilities, the fall is even greater, with a reduction of around 30% from the previous year. There is also a fall in the number of drilled exploration and production wells compared with the previous year. However, the number in 2016 is relatively high, at around 8% above the average for the period 2000-2015.

A presentation of DFUs or contributors to risk can sometimes vary according to whether absolute or "normalised" values are stated, depending on the normalisation parameter. In the main, normalised values are presented.

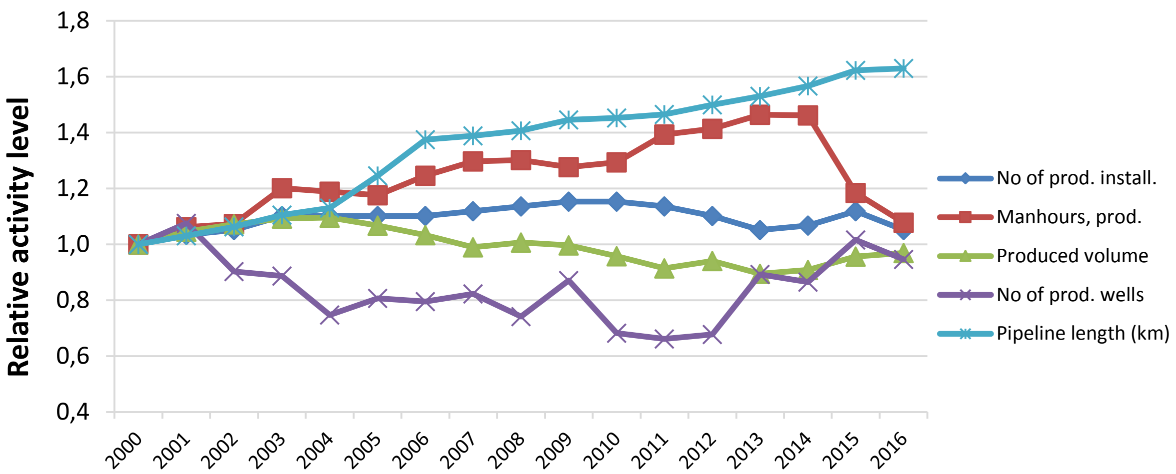


Figure 1 Relative trend in activity level for production facilities. Normalised against the year 2000.

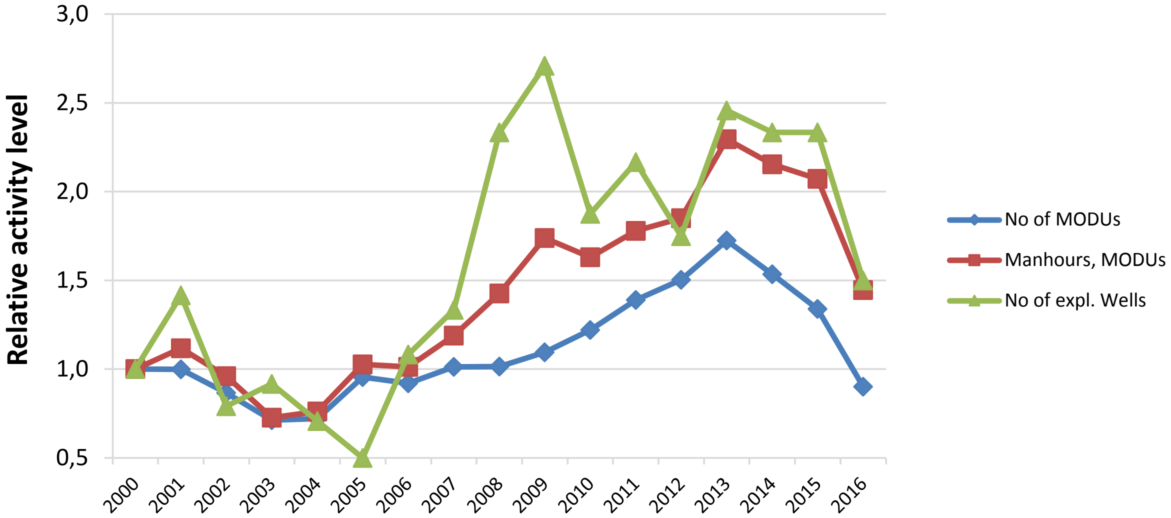


Figure 2 Relative trend in activity level for mobile facilities. Normalised against the year 2000.

A corresponding activity overview for helicopter transport is shown in sub-chapter 4.1.

3.4 Documentation

Analyses, assessments and results are documented as follows:

- Summary report – the Norwegian Continental Shelf for the year 2016 (Norwegian and English versions)
- Main report – the Norwegian Continental Shelf for the year 2016
- Report for onshore facilities for the year 2016
- Report for acute spills to sea for the Norwegian Continental Shelf 2016, to be published in the autumn of 2017
- Methodological report, 2017

The reports can be downloaded free of charge from the Petroleum Safety Authority Norway's website (www.ptil.no/rnnp).

4. Status and trends - DFU12, helicopter incidents

The cooperation with the Civil Aviation Authority and the helicopter operators was continued in 2016. Aviation data obtained from helicopter operators involved includes incident type, risk class, seriousness, type of flight, phase, helicopter type and information about departure and arrival. The main report (PSA, 2017a) contains additional information about the scope, constraints and definitions.

On 29/4/2016, a helicopter crashed on its way to land at Turøy in Øygarden. 13 people perished in the accident. The previous fatal helicopter accident on the NCS occurred on a flight to the Norne field in 1997. One consequence of the methodology used in RNNP is that actual accidents are handled in the same way as near-misses. Fatal accidents will affect any weighting used to assess the potential of future near-misses for causing loss of life. The Turøy accident is therefore included in incident indicator 1 as an incident with no remaining barriers and in incident indicator 2.

The activity indicators express how the exposure to helicopter risk is developing, and are thus a more leading indicator. The indicators are explained in detail in the main report.

4.1 Activity indicators

Figur 3 shows activity indicator 1 (transport service) as the number of flight hours and the number of person flight hours and activity indicator 2 (shuttle traffic) as the number of flight hours and number of passengers per year in the period 2000-2016.

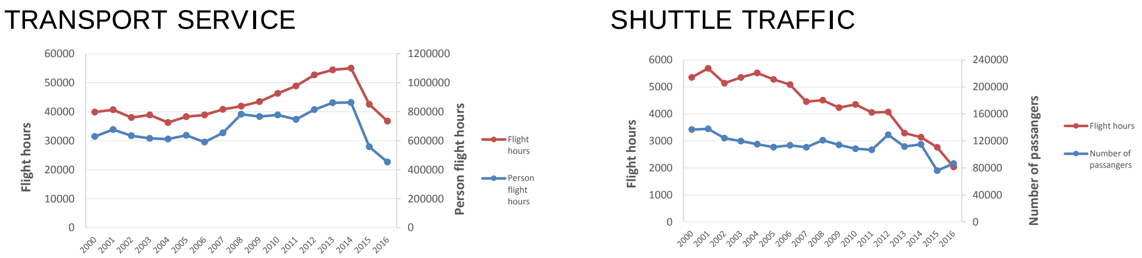


Figure 3 Flight hours and person flight hours (transport service) and number of passengers (shuttle traffic), 2000-2016

Flight hours in the transport service per year must be viewed in the context of the activity level on the NCS; see main report. From 2014 to 2016, the number of passengers fell by 40%, the number of person flight hours fell by 47%, while the number of working hours fell by 28%. In principle, there is a constant need for transport per working hour. The decline in both flight hours and person flight hours that we see in the indicator is however greater than what the fall in working hours should indicate.

Shuttle traffic comprises passenger transport in which the helicopter's departure and arrival concern a single facility. The fact that the number of passengers showed only a weak fall in the period 2000-2016, while the number of flight hours more than halved is explained by the helicopters carrying more passengers on each shuttle and shuttling shorter distances and with fewer stopovers.

4.2 Incident indicators

4.2.1 Incident indicator 1 – serious incidents and near-misses

Figur 4 shows the number of incidents included in incident indicator 1. From 2009 (and subsequently for 2006, 2007 and 2008), the most serious near-misses which the companies reported were reviewed by an expert group consisting of operational and technical personnel from the helicopter operators, from the oil companies and from the PSA's project group in order to classify the incidents based on the following categories:

Little remaining safety margin against fatal accident: *No remaining barriers*
Medium remaining safety margin against fatal accident: *One remaining barrier*

Large remaining safety margin against fatal accident: *Two (or more) remaining barriers*

In the expert group's assessment of incidents for 2016, there were two incidents with no remaining barriers. One is the Turøy accident and the other is an incident during taxiing in which a helicopter rotor brushed a parked lorry at Stavanger Airport. In the worst case, this could have caused the helicopter to flip.

The other incident is the Turøy accident that occurred on 29 April 2016 at Turøy in the municipality of Fjell in Hordaland in which 13 people, 2 pilots and 11 passengers, died. The helicopter was an Airbus EC225 LP Super Puma from CHC Helicopter Service and was on its way from Gullfaks B to Bergen Flesland Airport. It crashed after losing its main rotor, and the cause is most probably a fatigue fracture in the planetary gear in the gearbox. The incident is still under investigation by the Accident Investigation Board Norway.

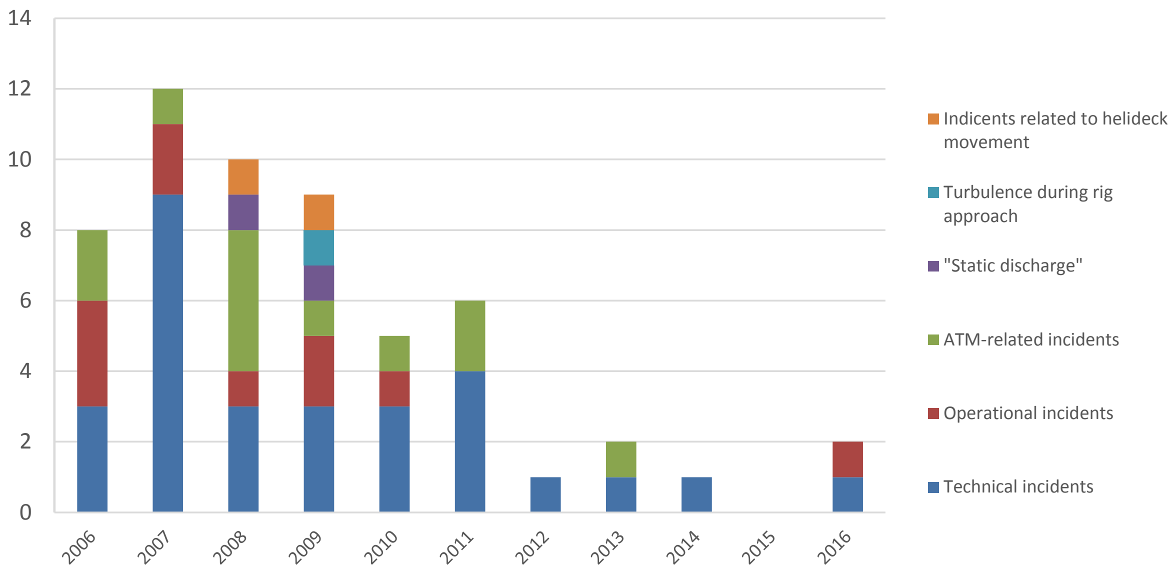


Figure 4 Incident indicator 1, incidents with little or medium remaining safety margin, 2006–2016

4.2.2 Incident indicators linked to causal categories.

As of 2009, there are three incident indicators based on causal categories, with the following content:

- Incident indicator 3:
  Helideck factors:
  - Incorrect information about position of helideck
  - Incorrect/missing information
  - Equipment failure
  - Turbulence
  - Obstacles in approach/departure sectors or on deck
  - Persons in restricted sector
  - Breach of procedures
  - Other
- Incident indicator 4:
  ATM aspects (air traffic management)
- Incident indicator 5:
  Bird strikes.

All degrees of severity beyond "no impact on safety" are included in these indicators. Figur 5 shows the number of incidents included in incident indicator 3, helideck factors. The change in the number of incidents for helidecks in 2015 and 2016 corresponds to the general increase in incidents in incident indicator 2. In all the years, there has been a preponderance of incidents on mobile facilities.

Figur 6 shows the number of incidents included in incident indicator 4, ATM aspects. Incidents included in incident indicator 4 rose sharply from 2010 to 2011, occurring in conjunction with an increased focus on deficient radio communication, which was the absolute largest single contributor to incident indicator 4 in 2011. The largest contributor in 2016 relates to misunderstandings between air traffic services and pilots, especially in relation to directional or altitude changes. There were also three incidents relating to near-misses, one of which was two helicopters on a collision course.

A new improvement suggestion was proposed in 2016:
The helicopter operators express their concern at the lack of focus on security measures at those sections of the airports where the helicopters are located. This defective passenger control relates in particular to non-offshore-related helicopter traffic. They recommend that the security measures at the airports concerning non-offshore-related helicopter traffic are reviewed in conjunction with the interested parties.

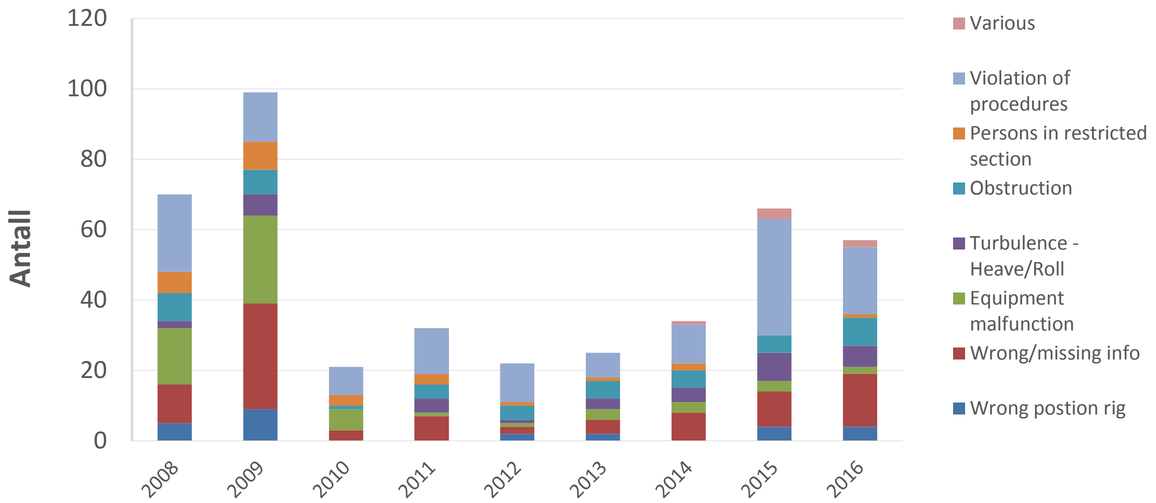


Figure 5 Helideck factors, 2008–2016

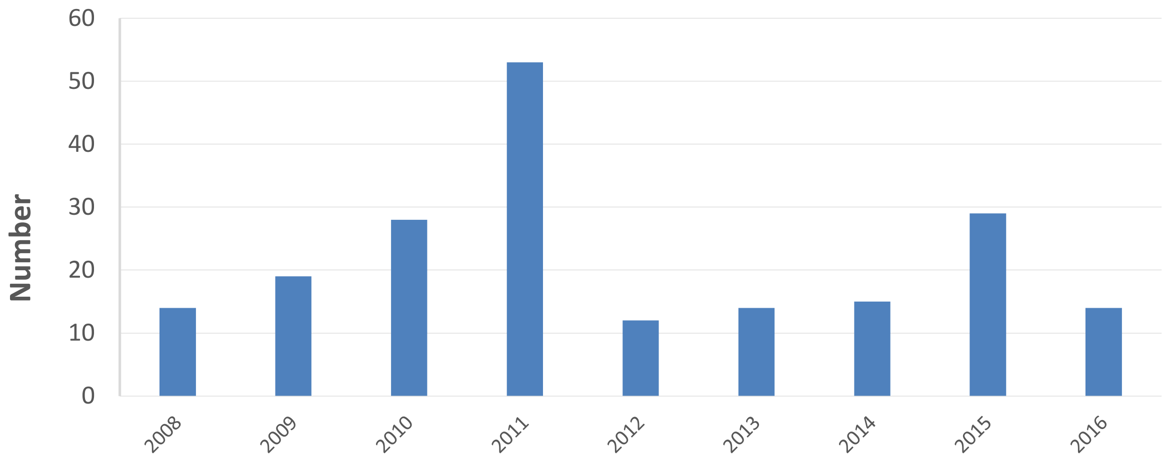


Figure 6 ATM aspects, 2008–2016

5. Status and trends – indicators for major accidents on facilities

The indicators for major accident risk from previous years have been continued, with a primary emphasis on indicators for incidents and near-misses with the potential for causing a major accident (DFU1-10). The indicators for DFU12, helicopter incidents, are presented separately in chapter 4. Barriers against major accidents are presented in chapter 6.

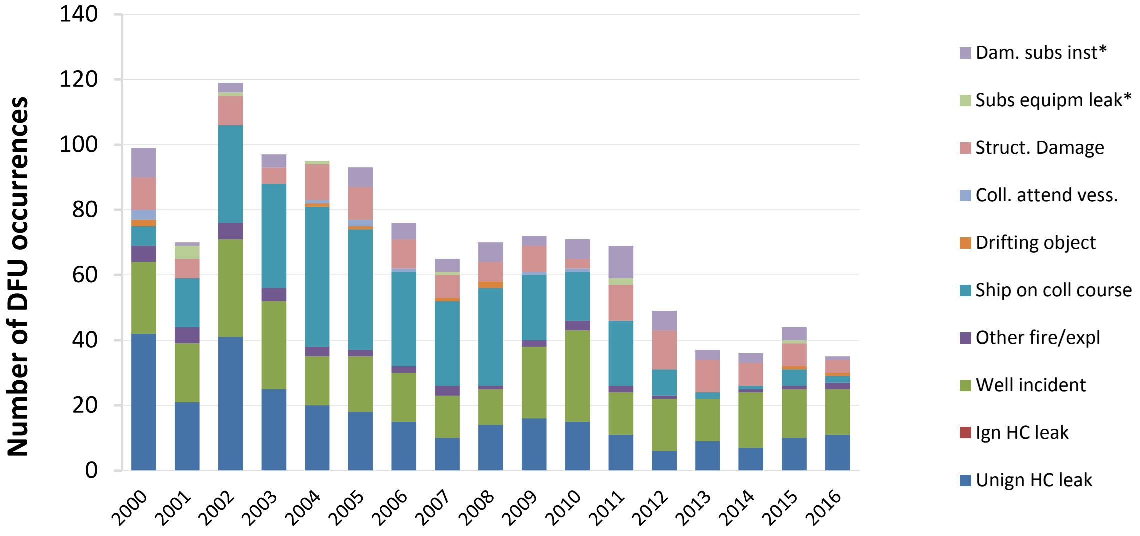
There have been no major accidents, per the definition used in the report, on facilities on the NCS since 1990. The serious incident on COSLInnovator where a wave stove in windows in an accommodation section, injuring 4 and killing one person, is categorised as a structural incident and is the first major accident DFU to have caused a fatality in the period. The last time there were any fatalities in connection with one of these major accident DFUs was in 1985, with a shallow gas blowout on the "West Vanguard" mobile facility.

The helicopter accident at Turøy in 2016 caused 13 fatalities. This incident is described more thoroughly in chapter 4 about the helicopter accident. As previously mentioned, helicopters (DFU12) are not included in the total indicator.

The most important individual indicators for production and mobile facilities are discussed in sub-chapter 5.2. The other DFUs are discussed in the main report. The indicator for total risk is discussed in sub-chapter 5.3.

5.1 DFUs associated with major accident risk

Figur 7 shows the trend in the number of reported DFUs in the period 2004-2016. It is important to emphasise that this figure does not take account of the potential of near-misses in respect of loss of life. This means that a fall in the total number of incidents does not necessarily entail a fall in the total indicator. There was a rising trend in the number of incidents during the period 1996-2000, which has been discussed in previous years' reports and is therefore omitted from the figure. After an apparent peak in the number of incidents in 2002, there is a gradual reduction in the number of incidents with major accident potential. Since 2013, the number of incidents of this type has been relatively stable per year. There was a small peak in 2015, but the number of incidents in 2016 is the lowest recorded in the period.



*Within the safety zone

Figure 7 Reported DFUs (1-10) by categories

In Figur 7, the number of incidents is presented without normalisation in relation to exposure data. Figur 8 shows the same overview, but now normalised against number of working hours. The value in 2016 is on a par with 2015, but clearly higher than 2014, which had the lowest recorded value in this period.

In Figur 8, a 90% prediction interval is used for 2016 based on an average value for the period 2007–2015 in order to indicate the degree of change in 2016. This means that the observations in 2016 are compared with the prediction interval based on the period 2007-2015. The calculation of prediction intervals is explained in detail in the methodology report (PSA, 2017c). As Figur 8 shows, the value in 2016 lies within the hatched area, which means that the value in 2016 is not significantly different from the average of the nine preceding years.

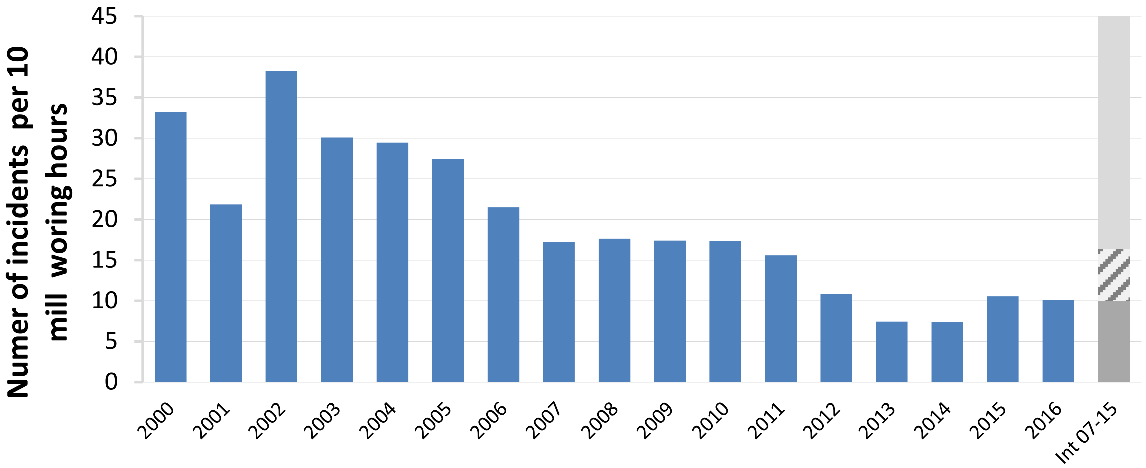


Figure 8 Total number of incidents DFU1-10 normalised against working hours

5.2 Risk indicators for major accidents

5.2.1 Hydrogen leak in the process area

Figur 9 shows the number of hydrocarbon leaks greater than 0.1 kg/s in the period 2000-2016. 11 hydrocarbons leaks were recorded in 2016, six in the category 1-10 kg/s and five in the category 0.1-1 kg/s.

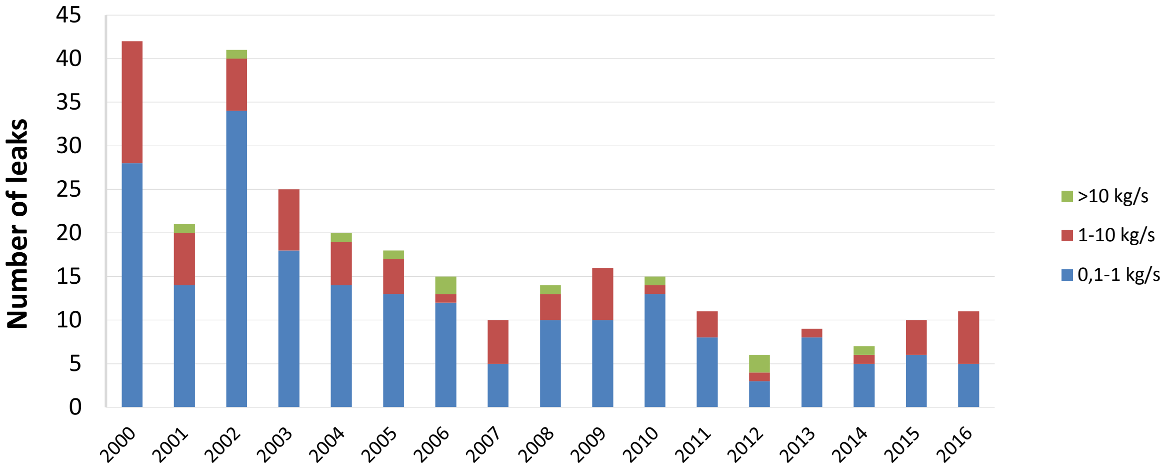


Figure 9 Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2016

Figur 10 shows the number of leaks when these are weighted according to the risk potential they are assessed as having. In simple terms, one can say that the risk contribution of each leak is roughly proportional to the leak rate expressed in kg/s. The relatively high risk contribution in 2016 derives from six incidents in the category 1-10 kg/s, with one leak in the upper level at a rate of 8 kg/s.

Figure 10 Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2016, weighted according to risk potential

Figur 11 shows the trend in leaks exceeding 0.1 kg/s, normalised against working hours for production facilities. The figure illustrates the technique used throughout to assess the statistical significance (validity) of trends. Figur 11 shows that, despite an increase in the number of leaks per facility year, in 2016 this parameter lies within the prediction interval. The change is therefore not statistically significant relative to the average for the period 2006-2015. This is indicated by the height of the column for 2016 being within the middle grey-hatched area in the column on the far right of the figure ("Int 06-15", see also the methodology report – PSA, 2017c). The number of leaks has been normalised both against working hours and against the number of facilities in the main report.

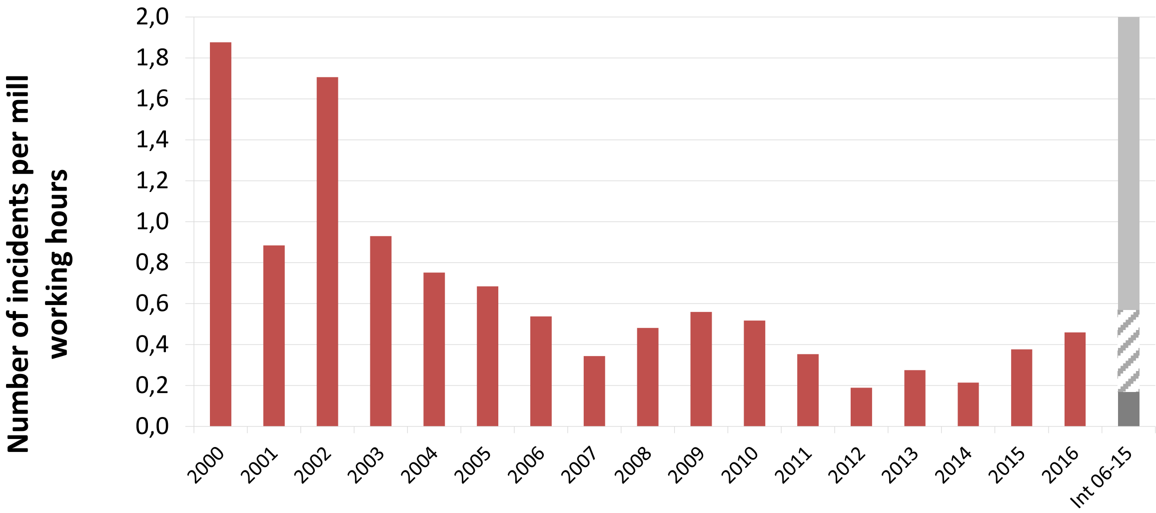


Figure 11 Trend, leaks, normalised against working hours

5.2.2 Loss of well control, blowout potential, well integrity

Figur 12 shows the occurrence of well control incidents broken down by exploration drilling and production drilling, normalised per 100 drilled wells.

For exploration drilling, there were major variations throughout the period. There has been a fall in the number of incidents per 100 drilled wells in the last two years, and in 2016 no well control incidents were recorded within exploration drilling.

There was an increase in the number of production drilling incidents from 2013 to 2016. The level in 2016 is however not statistically significant compared with the average of the preceding ten years. Out of the total of 14 well control incidents in 2016, 12 incidents are classified as level 3 low severity, one as level 2 medium severity, and one as level 1 high severity (see the methodology report for a description of the well incident categories). The high-severity incident occurred on the Songa Endurance mobile drilling facility in connection with work on a production well on the Troll field in the North Sea, where Statoil is the operator. It is assessed that this incident had a high probability of leading to a blowout, meaning that this incident is given a high weighting in the risk indicator.

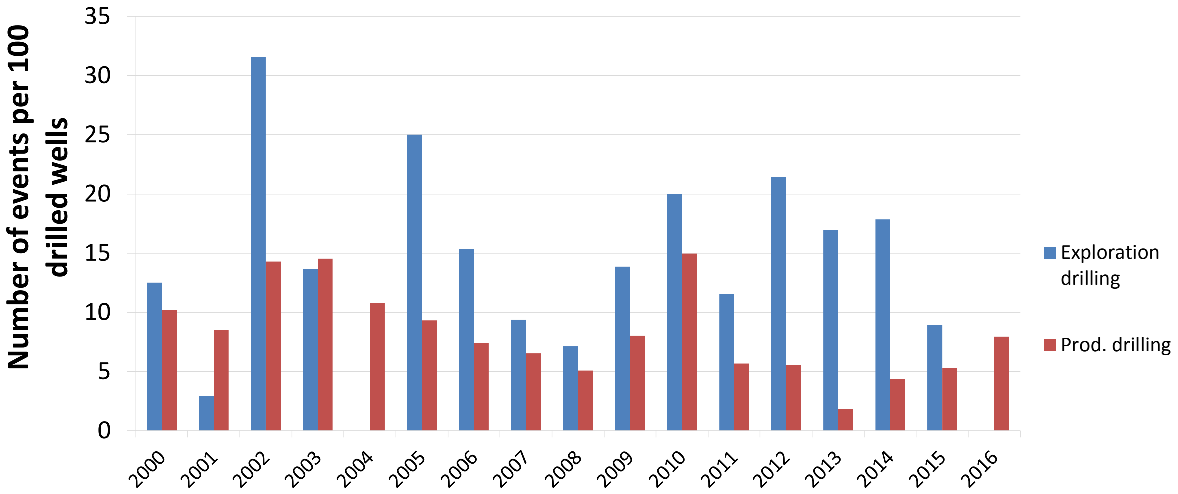


Figure 12 Well incidents per 100 wells drilled, for exploration and production drilling

Figur 13 shows the trend in weighted risk of loss of life normalised against working hours in the observation period for exploration and production drilling combined. The figure shows that in 2016 there was very high risk associated with well control incidents. This high risk relates primarily to the well control incident on the Troll field. In spite of a fall in the number of incidents in the last two years, an increase in risk is to be seen as a consequence of one of the incidents in 2016 having a high probability of developing into a blowout.

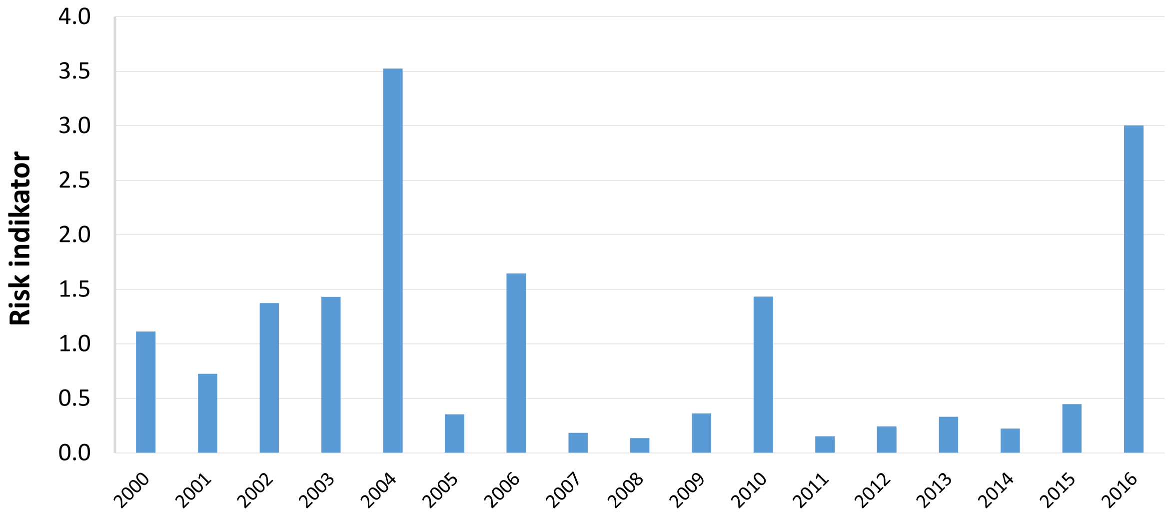


Figure 13 Risk indicators for well control incidents in exploration and production drilling, 2000-2016

In 2007, the Well Integrity Forum (WIF) established a pilot project for key performance indicators (KPIs) for well integrity. The operating companies have reviewed all their "active" wells on the NCS, a total of 1,943 wells in 2016, with the exception of exploration wells and permanently plugged wells (a total of 13 operating companies). This was first reported in accordance with WIF's list of well categories in 2008, based on current definitions and subgroups per category. WIF uses the following well categories;

Red: one barrier failed and the other is degraded/not verified or with external leaks
Orange: one barrier failed and the other is intact, or a single failure could cause a leak to the surroundings
Yellow: one barrier leaks within the acceptance criteria or the barrier has been degraded, the other is intact
Green: intact well, no or insignificant integrity aspects.

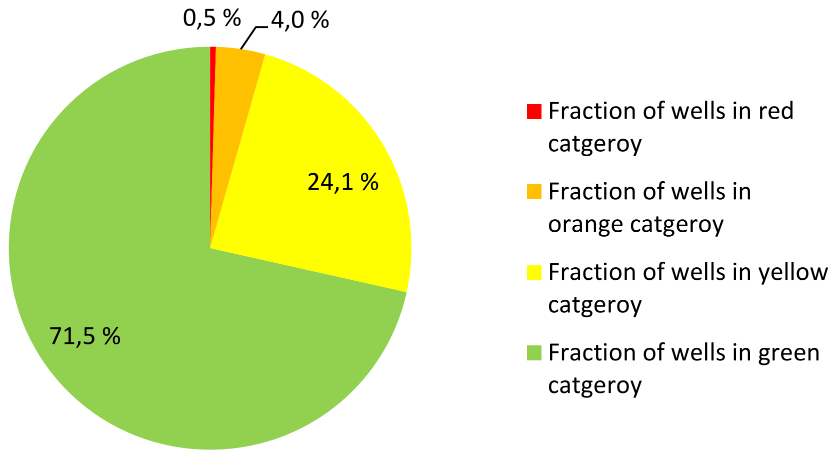


Figure 14 Well categories

The mapping shows an overview of well categories distributed according to the percentage of the total sample of 1,943 wells.

The categorisation shows that 28.5% of the wells included in the mapping have degrees of weakness of integrity. Wells in the red and orange categories have reduced quality in respect of the two-barrier requirement. 9 wells (0.5%) were recorded in the red category and 77 wells (4%) in the orange category. The red category includes injection and production wells, while the orange category also includes temporarily plugged wells under monitoring. Wells in the yellow category have reduced quality in respect of the requirement for two barriers, but the companies have compensated for this through various measures such that they are deemed to comply with the two-barrier requirement. There are 468 wells (24.1%) in the yellow category.

There was an increase in the number of wells in the three highest categories from 24% to 31% in the period 2009-2015, before a fall to 28.5% in 2016. The development in the different categories is shown in Figur 15.

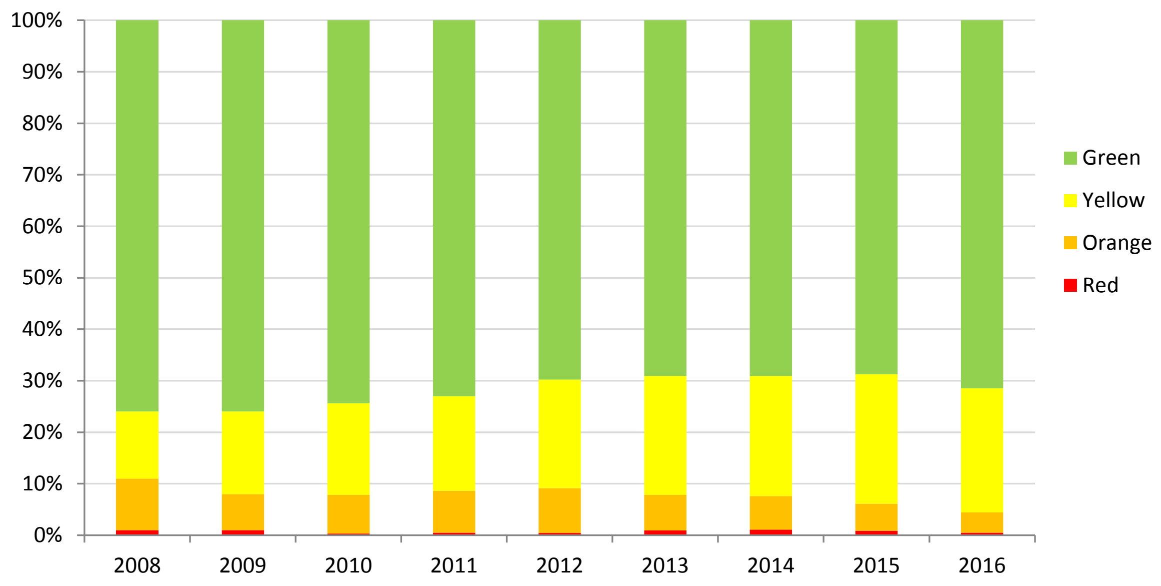


Figure 15 Development in well categories, 2009-2016

5.2.3 Leak/damage to risers, pipelines and subsea facilities

In 2016, no leaks from risers to production facilities were reported. Nor were any leaks from pipelines reported in 2016. For subsea facilities, a number of minor spills of hydraulic fluid and some small hydrocarbon leaks were reported. These leaks were, however, outside the safety zone and caused no risk to personnel.

There was one incident of serious damage to pipelines and risers in 2016. There was no serious damage to subsea facilities.

Serious damage to risers and pipelines is included in the calculation of the total indicator, but with a lower weighting than for leaks. Figur 16 shows an overview of the most serious incidents of damage within the safety zone during the period 2000-2016.

Figure 16 Number of incidents involving serious damage to risers & pipelines within the safety zone, 2000-2016

5.2.4 Ship on collision course, structural damage

There are only a few production facilities and just a few more mobile facilities where the facility itself or the standby vessel are responsible for monitoring passing ships on a potential collision course. The others are monitored from the traffic centres at Ekofisk and Sandsli.

The indicator for ships on potential collision courses is normalised according to the number of facilities monitored from the traffic centre at Sandsli, expressed as the total number of monitoring days for all facilities monitored by Statoil Marine at Sandsli. The number of instances of ships on collision courses has declined substantially in recent years. In 2016, a total of two ships on collision courses were recorded.

As regards collisions between vessels associated with the petroleum activities and facilities on the NCS, there was an elevated level in 1999 and 2000 (15 incidents each year). Statoil in particular has worked hard to reduce such incidents, and in recent years, the number has been around two to three per year.

There was one collision incident in 2016. Since this was with an unmanned unit during removal, the incident caused no risk to personnel, and the collision was not counted as an incident in 2016.

Major accidents associated with structures and maritime systems are rare. Even though there have been several very serious incidents in Norway, there are too few to gauge trends. Accordingly, incidents and damage of lesser severity have been selected as measures of changes in risk. It is also assumed that there is a connection between the number of minor incidents and the most serious; see the methodology report.

The current regulations set requirements for flotels and production facilities in terms of withstanding the loss of two anchor lines without serious consequences. Loss of more than one anchor line happens from time to time. This may have major consequences, but rarely as great as on *Ocean Vanguard* in 2004. Mobile drilling facilities are required to withstand the loss of one anchor line without undesirable consequences.

Structural damage and incidents that have been included in RNNP are primarily classified as fatigue damage, and some are storm damage. As regards cracks, only continuous structural cracks are included. No clear connection has been demonstrated between the age of the facility and the number of cracks. The number of DFU8 incidents during the period 2000-2016 is shown in Figur 17.

In 2016, a total of four structural incidents were recorded, one relating to anchor lines and three wave impact incidents. None of the incidents in 2016 is categorised as especially serious. The fall in the number of incidents is connected with the large decline in the number of mobile facilities on the NCS.

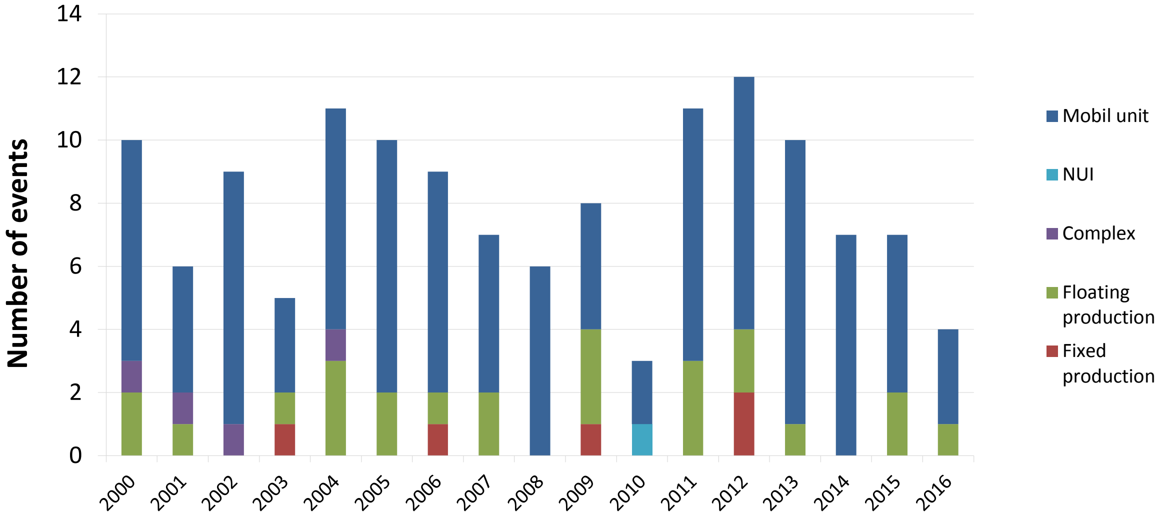


Figure 17 Number of serious incidents and incidents involving damage to structures and maritime systems which conform to the criteria for DFU8

5.3 Total indicator for major accidents

The total indicator applies to major accident risk on facilities, whereas risk associated with helicopter transport was discussed in chapter 4. The calculation model assigns the DFU-related incidents a weighting based on the probability of a fatal accident if the incident develops. It is emphasised that this indicator is only a supplement to the individual indicators, and expresses the development in factors related to major accidents. In other words, the indicator expresses the effects of risk management.

The total indicator weights the contributions from the observations of the individual DFUs according to the potential for loss of life (see the pilot project report), and will therefore vary considerably, based on the potential of the individual incidents. Figur 19 shows the indicator for production facilities with annual values, in addition to a three-year rolling average. The large variations from year to year are reduced when viewing the three-year rolling average, thereby clarifying the underlying trend. Working hours are used for normalising against activity level. The level of the normalised value was set at 100 in the year 2000, which also applies to the value for the three-year rolling average.

Figur 18 shows that the total indicator for 2016 is at an equivalent level to 2015. This level is higher than in 2013 and 2014, but not significantly higher in comparison with the period 2006-2015.

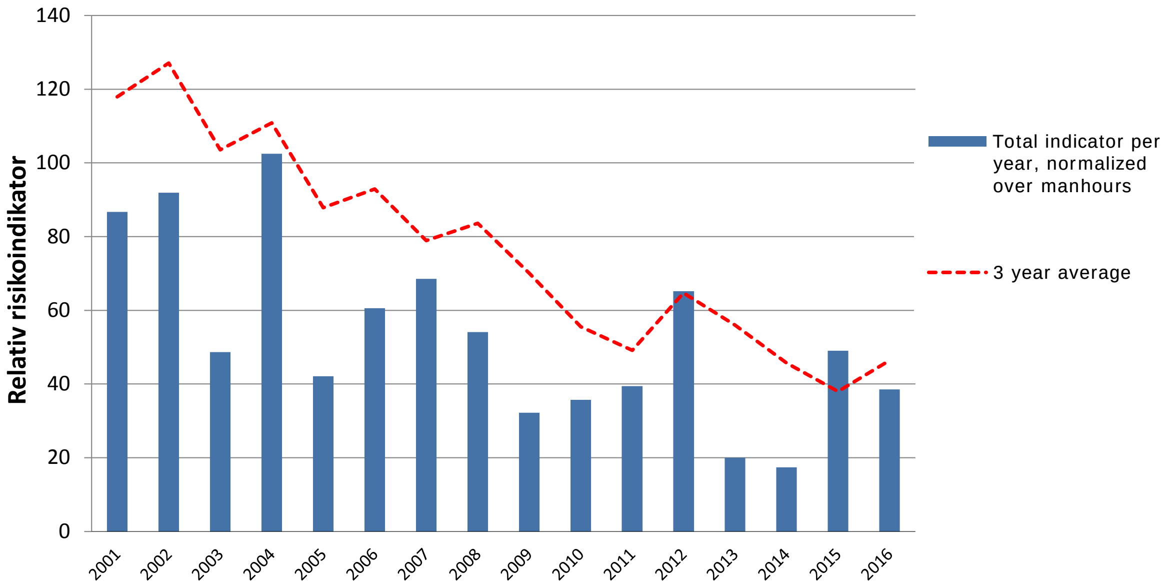


Figure 18 Total indicator for major accidents per year, normalised against working hours, annual values and three-year rolling average

For production facilities, looking at the three-year average, the main impression is of a relatively constant level until 2004. From 2005 to 2012, the level has been fairly constant at a lower level and slightly declining. In 2013 and 2014, the total indicator was at a relatively lower level. Individual incidents with considerable risk potential may cause large variations and have an effect over three years, due to the averaging, as the figure clearly shows for 2004 (the blowout at Snorre A) and 2010 (the well incident at Gullfaks C). In 2013 and 2014, there were no very serious incidents and the total number of incidents is relatively low. In 2015, a number of serious incidents contributed to a rise in the level of the total indicator. In 2016, the indicator is at the same level as 2013 and 2014.

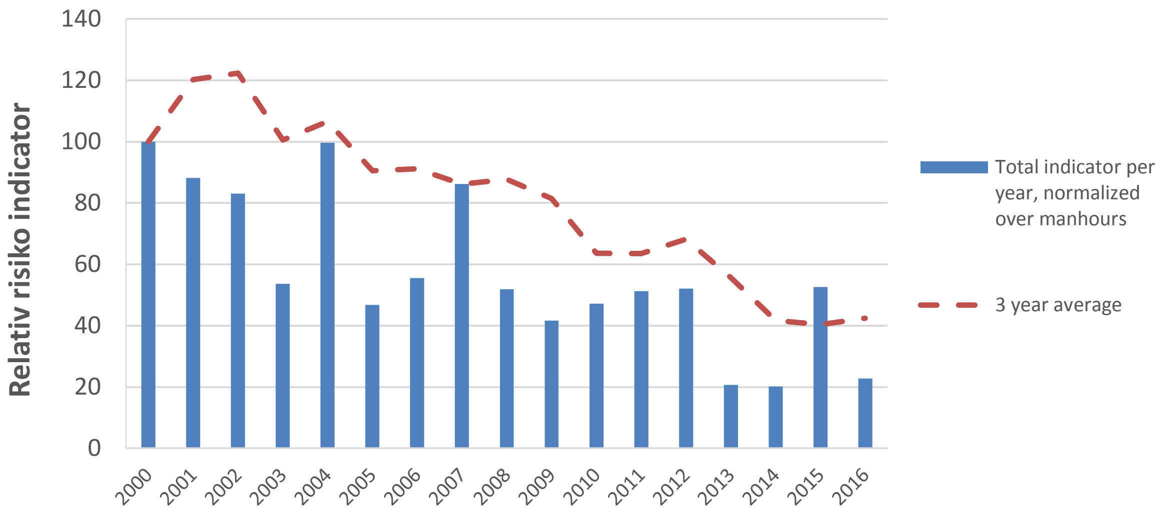


Figure 19 Total indicator, production facilities, normalised against working hours, annual values and three-year rolling average

Figur 20 shows the trend in the total indicator for mobile facilities with annual values and three-year rolling average. The variations are greater than for the production facilities. With the exception of 2012, the values in the period 2009-2014 are at a low level. In 2012, the increase was significant due primarily to structural incidents. From the annual values, it can be observed that the value in 2016 is higher than in the three preceding years. The contribution from structural damage and incidents involving maritime systems has been high on mobile facilities for many years. In 2016, the main contribution is from well control incidents.

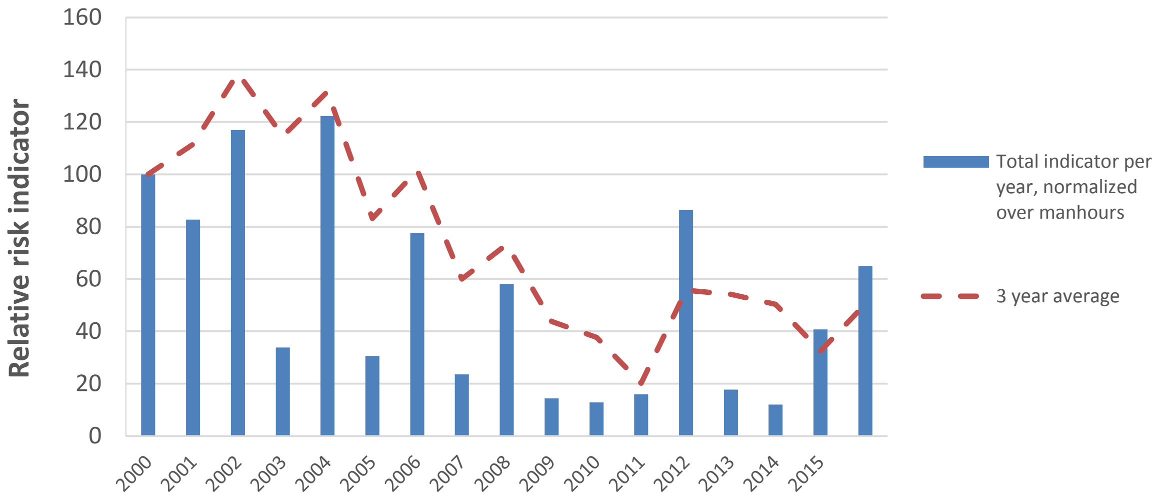


Figure 20 Total indicator, mobile facilities, normalised against working hours, annual values and three-year rolling average

6. Status and trends – barriers against major accidents

Reporting and analysis of data concerning barriers has been continued from preceding years without significant adjustments. As previously, the companies report test data from routine periodic testing of selected barrier elements.

6.1 Barriers in the production and process facilities

There is primary emphasis on barriers relating to leaks from the production and process facilities, including the following barrier functions:

- Integrity of hydrocarbon production and process facilities (covered to a considerable degree by the DFUs)
- Prevent ignition
- Reduce clouds/emissions
- Prevent escalation
- Prevent any fatalities

The different barriers consist of several interacting barrier elements. For example, a leak must be detected before isolation of ignition sources and emergency shutdown (ESD) is initiated.

Figur 21 shows the proportion of failures for the barrier elements associated with production and processing and for which test data have been collected. The test data are based on reports from all production operators on the NCS. In addition, the associated industry standard for each barrier element is shown.

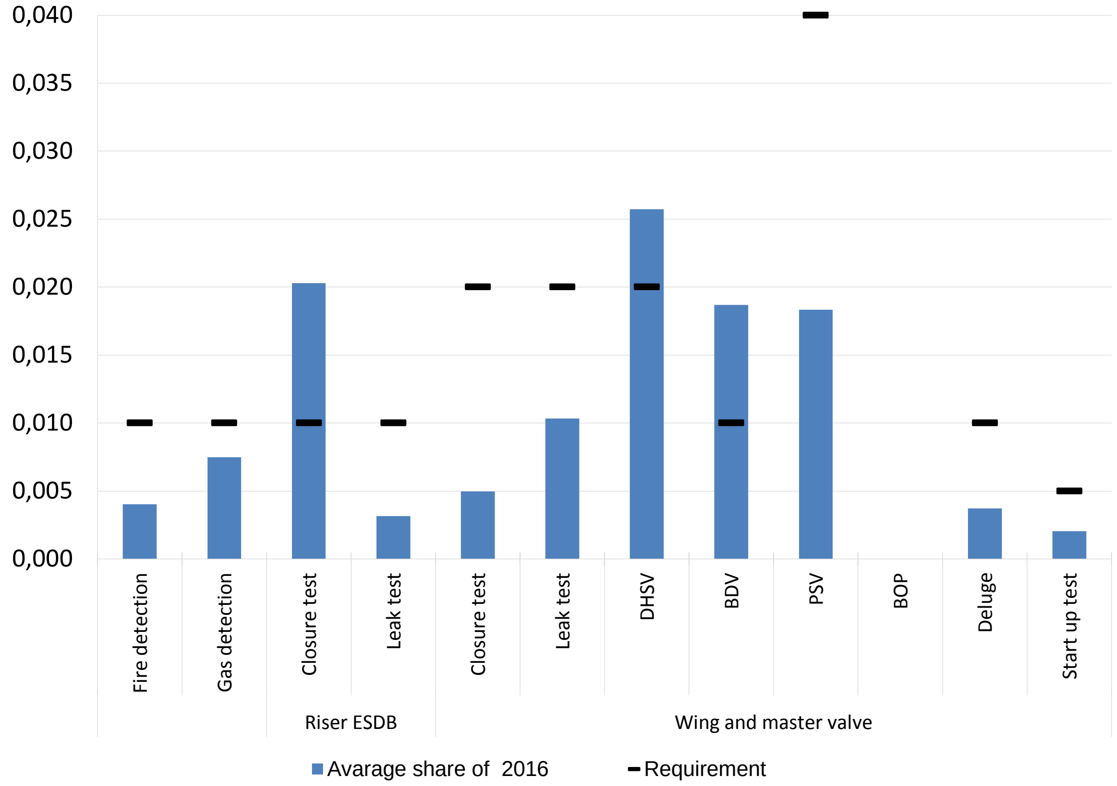


Figure 21 Mean percentage of failures for selected barrier elements in 2016

The main report shows both the "mean percentage of failures" (Figur 21), i.e. the percentage of failures for each facility individually, averaged for all facilities, and the "overall percentage of failures", i.e. the sum of all failures on all reporting facilities, divided by the sum of all tests for all reporting facilities. All facilities have the same contribution to the mean percentage of failures, regardless of how many tests they have.

The data show considerable variations in average levels for each of the operating companies, and for several of the barrier elements. The variations are even greater when one looks at each individual facility, as has been done for all barrier elements in the main report. Figur 22 shows an example of one such comparison for testing emergency shutdown valves (ESDVs) on risers and flowlines. Each individual facility is assigned a letter code, and the figure shows the percentage of failures in 2016, the average percentage of failures during the period 2007-2016, as well as the total number of tests carried out in 2016 (as text on the X axis, along with the facility code). The figure shows that, with a few exceptions, few failures were registered on the riser ESDV closure test in 2016.

The industry standard for riser ESDV closure tests is 0.01. Figur 22 shows that eight facilities are above the industry standard for percentage failures in 2016, while 20 facilities were above the industry standard for the period 2007-2016 as a whole.

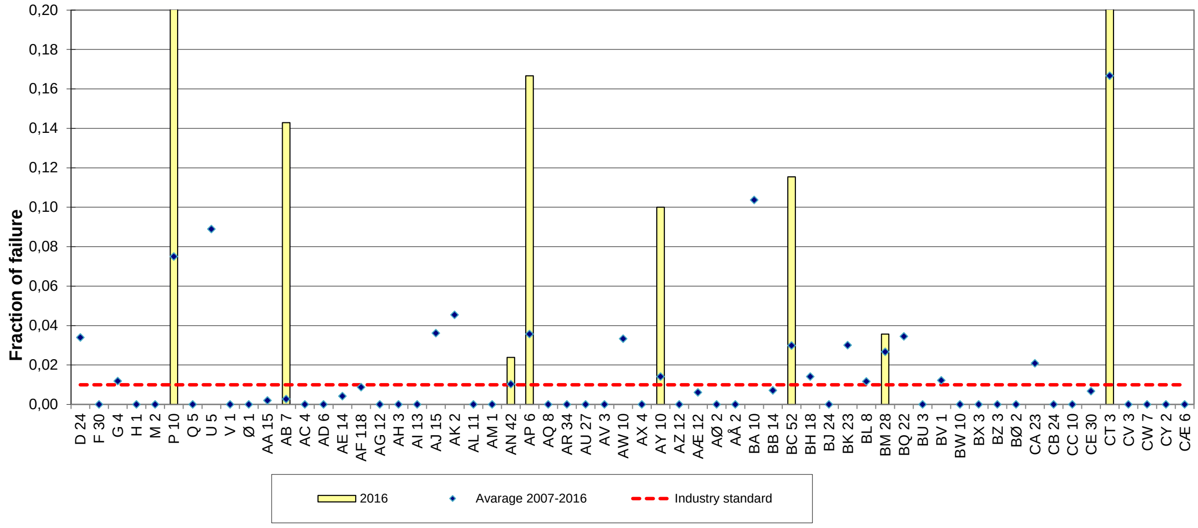


Figure 22   Percentage of failures for riser ESD valves (closure test)

As regards production facilities, barrier data has now been collected for 13 years for most barriers. Overall, there are many individual facilities which, for certain barrier elements, have performed worse or considerably worse than the industry standards, both in 2016 and on average for the whole period. With the industry's focus on preventing major accidents, a further improvement in this areas should be expected. For the industry as a whole, a positive trend has been observed for some of the barriers that have been above the industry standard in recent years.

Tabell 2 shows how many facilities have carried out tests for each barrier element, the total number of tests, the average number of tests for the facilities that have carried out tests, the overall percentage of failures and the mean percentage of failures for 2016 and for the period 2002-2016. This can then be compared with availability requirements for safety-critical systems. Figures in bold indicate that the percentage of failures exceeds the industry standard.

The table shows that, overall, most barrier elements are below or about on a par with the industry standard for availability. As in the previous year's RNNP report, the mean percentage of failures for 2016 and the mean percentage of failures for 2002-2016 for riser ESDVs, DHSVs and blowdown valves (BDVs) are above the industry standard. The same applies to the mean percentage of failures for 2002-2016 for deluge valves. Deluge valves were above the industry standard for both indicators in 2014 and 2013.

Table 2 General calculations and comparison with industry standards for barrier elements

Barrier elements	Number of facilities where tests were performed in 2016	Average, number of tests, for facilities where tests were performed in 2016	Number of facilities with percentage failures in 2016 greater than the industry standard	Number of facilities with average percentage failures 2002-2016 greater than the industry standard*[1]	Total percentage failures in 2016	Mean percentage failures in 2016	Total percentage failures 2002-2016	Mean percentage failures 2002-2016	Industry standard for availability (Statoil)
Fire detection	72	657	2	4	0.002	0.004	0.003	0.004	0.01
Gas detection	73	367	14	16	0.007	0.007	0.007	0.008	0.01
Shutdown:									
• Riser ESDV	61	22	11	28	**0.015**	**0.012**	**0.014**	**0.019**	0.01
Closure test	60	13	8	20	**0.019**	**0.020**	**0.012**	**0.019**	0.01
Leak test	60	8	3	16	0.010	0.003	**0.013**	**0.014**	0.01
• Wing and master (Christmas tree)	73	222	7	6	0.008	0.010	0.008	0.010	0.02
Closure test	72	109	5	4	0.008	0.005	0.006	0.007	0.02
Leak test	73	115	8	8	0.008	0.010	0.009	0.011	0.02
• DHSV	73	119	25	28	**0.023**	**0.026**	**0.021**	**0.021**	0.02
Blowdown valve (BDV)	61	59	27	36	**0.021**	**0.019**	**0.020**	**0.022**	0.01
Pressure safety valve (PSV)	69	162	9	13	0.019	0.018	0.030	0.025	0.04
Isolation using BOP	17	204	-	-	0.000	0.000	0.006	0.017	*[2]
Active fire safety:									
• Deluge valve	72	32	8	23	0.005	0.004	0.009	**0.011**	0.01
• Start test	62	124	7	13	0.001	0.002	0.002	0.003	0.005

[1] For *closure tests* and *leak tests* for riser ESDVs and wing and master valves, the average is from 2007, for PSVs and BDVs, the average is from 2004.
[2] For isolation using BOP, there is no comparable requirement, as an availability requirement is not considered to be appropriate. Statoil's internal guidelines recommend following up failures in this barrier using trend analysis.

6.2 Barriers associated with maritime systems

In 2016, data were collected for the following maritime barriers on mobile facilities:

- Watertight doors
- Valves in the ballast system
- Deck height (air gap) for jack-up facilities
- GM values for floating facilities at year-end.
- KG values are also collected during the year, but will not be used until next year.

Data collection was carried out for both production and mobile facilities. There are considerable variations in the number of tests per facility, from daily tests to twice per year. In recent years, approx. 1,000 annual tests of watertight doors and approx. 6,000 tests of ballast valves on mobile facilities have been carried out.

The number of valve failures in the ballast system in 2015 and 2016 rose somewhat from the level in 2014, although it is considerably lower than the high level in 2013. The number of tests of valves in the ballast system is at around the same level as in 2014 and 2015. The percentage of failures of watertight door closures has increased each year until 2013. For 2014, the percentage of failures fell considerably and has remained at the same low level in subsequent years. Only three failures were recorded in the three-year period 2014-2016.

6.3 Maintenance management

Globally, defective or deficient maintenance has often proved to be a contributory cause of major accidents. It is because of the major accident potential that safety work in general and the maintenance of safety-critical equipment in particular has been given so much emphasis in the petroleum industry. One aim of maintenance management is to identify critical functions and ensure that safety-critical barriers work when required.

Since 2010, we have collected data from industry participants in order to monitor trends in selected indicators. By emphasising aspects of the present situation and the trend over time, we can concentrate in future work on selected areas. It is however the individual participant who is responsible for regulatory compliance and ensuring systematic HSE efforts, so as to reduce the risk of unwanted incidents and major accidents.

The main report shows more graphs of participants' maintenance management than are reproduced here.

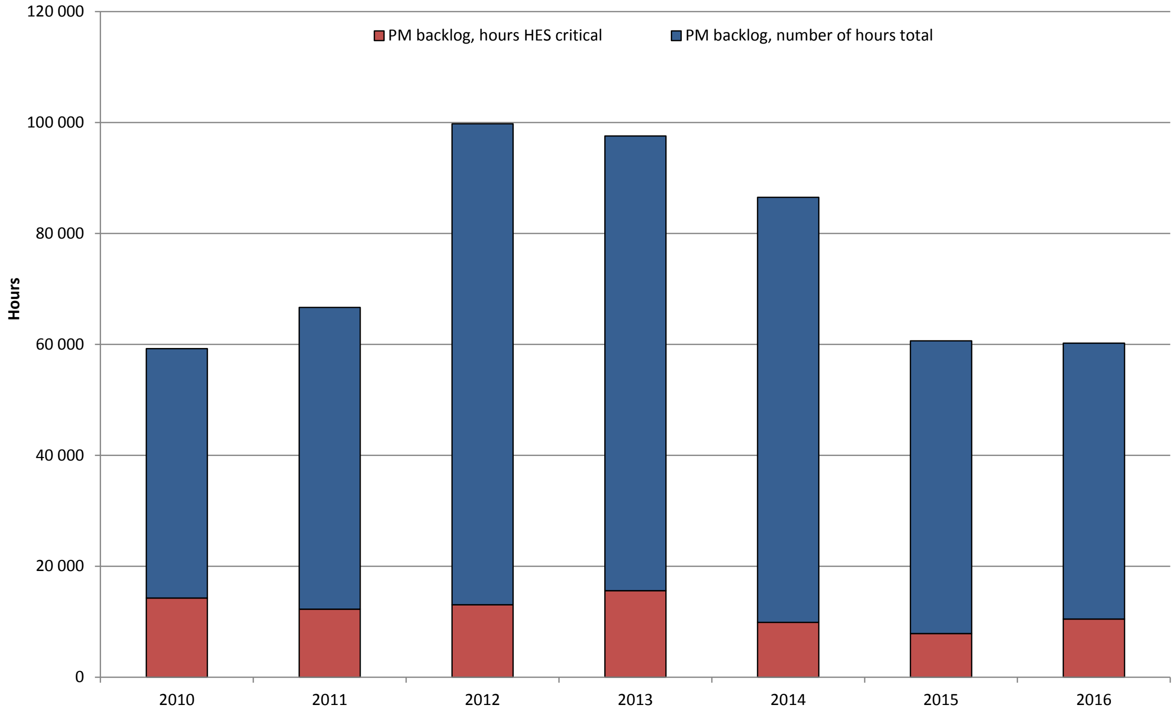


Figure 23 Total backlog in PM per year in the period 2010-2016 for the permanently fixed facilities on the NCS

Figur 23 shows that the total backlog in preventive maintenance for 2016 is around the same as for 2015, but there is a small increase in the backlog for HSE-critical equipment.

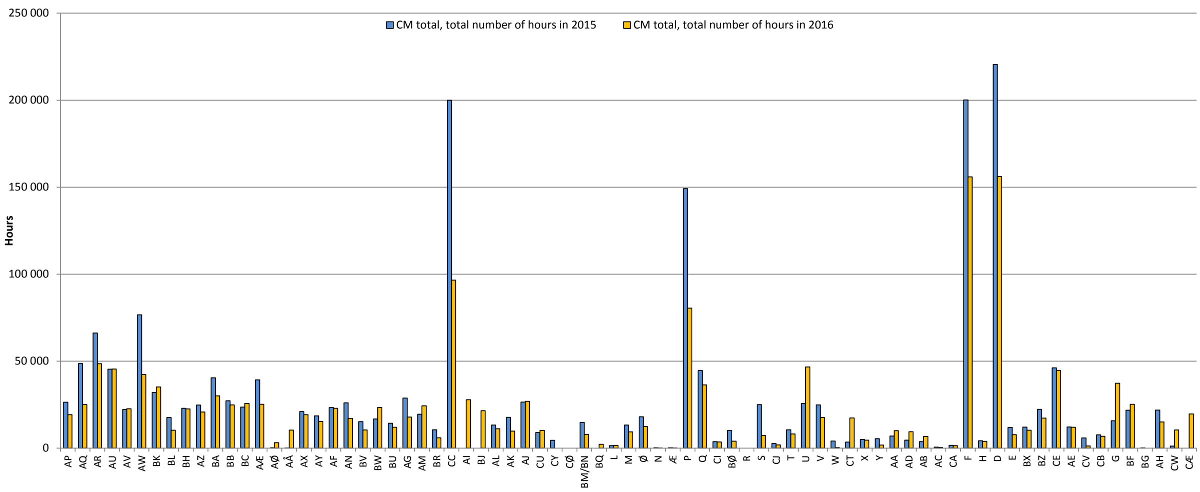


Figure 24 Total CM at 31/12/2015 for the permanently fixed facilities on the NCS. The figure also shows data for 2015

Figur 24 shows that some facilities still have a considerable number of hours of corrective maintenance not completed at 31/12/2016, but we can also see that the hours figures show some considerable reductions compared with the previous year.

Total outstanding HSE-critical maintenance shows a clear reduction in 2016 compared with the previous years. Maintenance of this type of equipment should not exceed the defined deadlines since HSE-critical equipment is intended to inhibit or restrict the defined hazard and accident situations.

In a meeting with selected operating companies in November 2015, it emerged that some companies had reported figures for outstanding corrective maintenance in a way that made it difficult to compare the figures across facilities and operators.

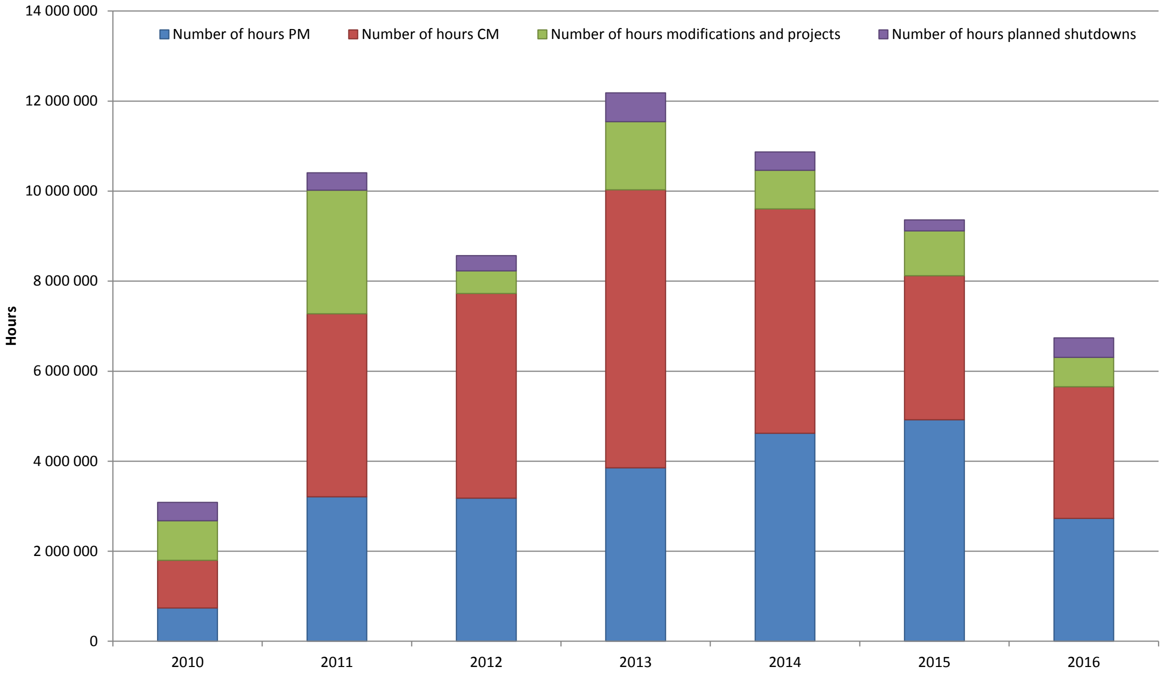


Figure 25 Total number of hours for performed maintenance, modifications and planned shutdowns for the permanently fixed facilities in the period 2010-2016. Not all the participants reported figures for 2010

Figur 25 is especially intended to show the distribution of the maintenance activities. We can see that the hours of preventive maintenance performed have fallen considerably in 2016 compared with recent years. Hours of corrective maintenance performed are also somewhat lower in 2016 than the preceding year, but the reduction is much less than for preventive maintenance.
We note that:

- some of the tagged equipment is not classified, but that this proportion has gradually fallen in the period 2010-2016
- there are few hours of backlog in preventive maintenance, but that a number of facilities have not performed HSE-critical preventive maintenance in accordance with defined deadlines
- some facilities still have a considerable number of hours of corrective maintenance unperformed at 31/12/2016, but the number of hours is significantly reduced in some instances in 2016
- there is a fall in the total of outstanding HSE-critical corrective maintenance in 2016 compared with previous years
- hours of preventive maintenance performed have fallen considerably in 2016 compared with recent years. Hours of corrective maintenance performed are also somewhat lower in 2016 than the preceding year, but the reduction is much less than for preventive maintenance.

These observations must be seen in the context that:

- plant, systems and equipment must be tagged and classified so as to facilitate safe operation and prudent maintenance, including maintaining the performance of the barriers
- the activity level on the facility must take account of the status of maintenance performance. Status is this context includes the backlog of preventive maintenance and the outstanding corrective maintenance
- the significance of unperformed maintenance must be assessed both individually and in combination. The assessment is crucial for determining the extent to which unperformed maintenance entails increased risk
- the backlog in the HSE-critical preventive maintenance may contribute to increased uncertainty with regard to technical condition, and hence increased risk
- corrective maintenance of HSE-critical equipment should not exceed the defined deadlines since it is the HSE-critical equipment that is intended to inhibit or restrict the defined hazard and accident situations

Figur 26 shows large variations in the backlog of preventive maintenance for the mobile facilities. This corresponds to what we have seen in recent years. Several facilities have not performed HSE-critical preventive maintenance in accordance with defined deadlines. This may contribute to increased uncertainty in respect of technical condition and increased risk, with respect to the significance of maintenance for protecting critical functions and ensuring that HSE-critical equipment works when called upon.

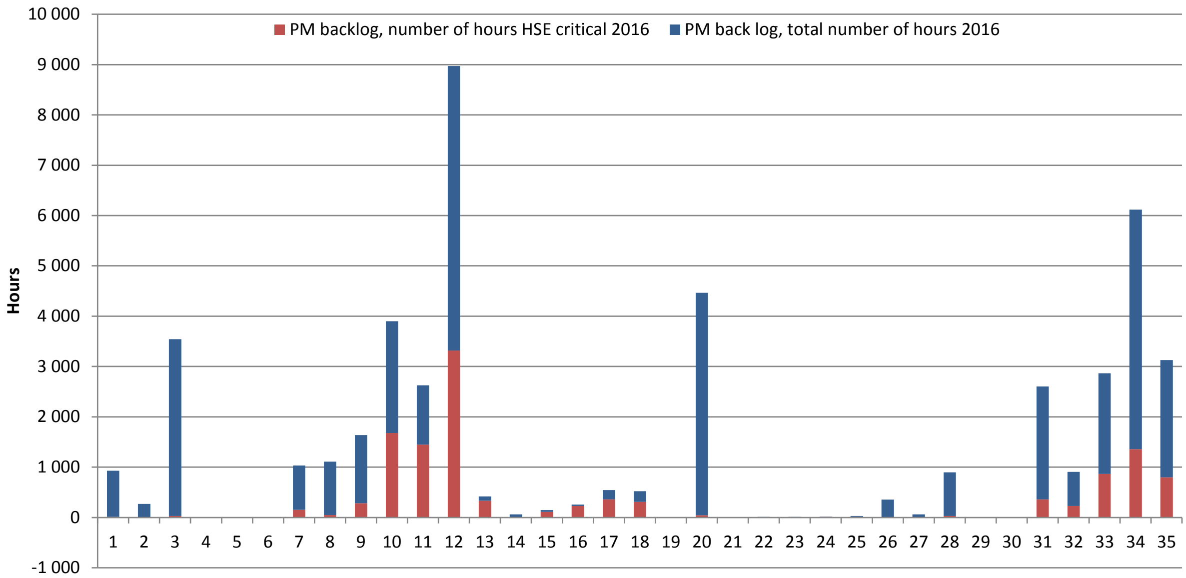


Figure 26 The backlog in PM per facility in 2016 for the mobile facilities

Figur 27 shows the *outstanding corrective maintenance* per facility in 2016.

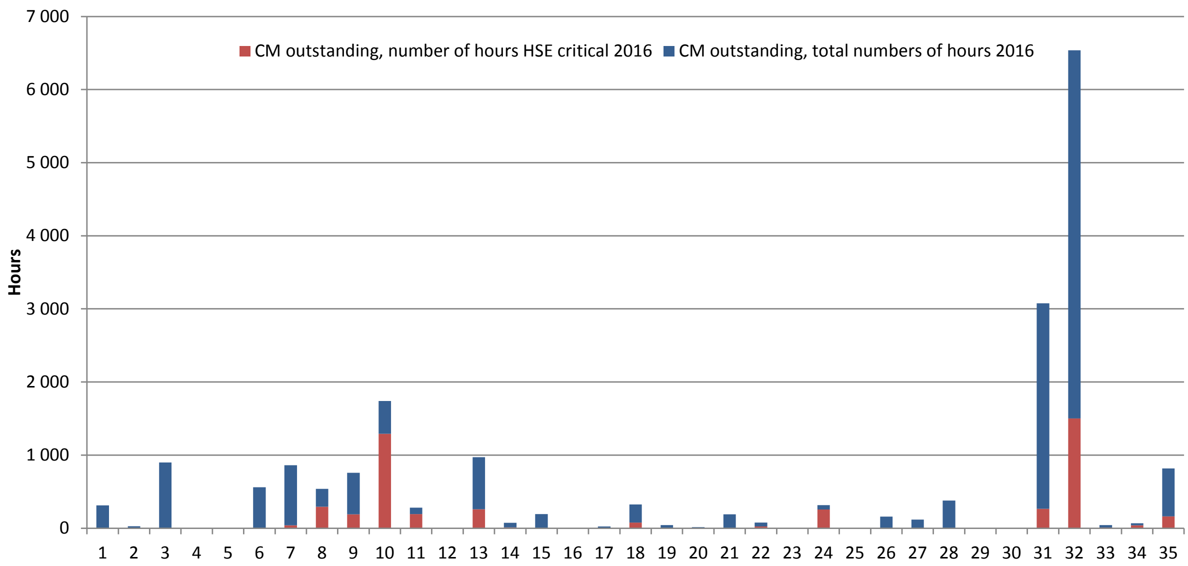


Figure 27 The outstanding CM per facility in 2016 – mobile facilities

Figur 27 shows large variations in outstanding corrective maintenance for the mobile facilities. This corresponds to what we have seen in recent years. Several facilities have not performed HSE-critical corrective maintenance in accordance with defined deadlines.

The data for maintenance management on mobile facilities show a certain increase for some facilities in terms of the number of tagged and classified pieces of equipment. The data show large variations in the backlog of preventive maintenance and in outstanding corrective maintenance per facility. This corresponds to what we have seen in recent years. We took this up with the participants last year and will follow it up further this year.

7. Status and trends – work accidents involving fatalities and serious personal injuries

There were no fatal accidents within the PSA's area of authority on the NCS in 2016, but on 29 April 2016, 13 people died when a Super Puma helicopter crashed while transporting oil workers from Gullfaks B to Flesland. For 2016, the PSA registered 191 personal injuries on facilities in the petroleum activities on the NCS that fulfil the criteria of fatality, absence into the next shift or medical treatment. In 2015, 258 personal injuries were reported.

In addition, 25 injuries classified as off-work injuries and 25 first aid injuries were reported in 2016. For comparison, in 2015 there were 34 off-work injuries and 32 first aid injuries. First aid injuries and off-work injuries are not included in figures or tables in this chapter.

In recent years, we have seen a reduction in the number of injuries reported on the NAV (Norwegian Labour and Welfare Administration) forms, and this trend continued in 2016. 38% of the injuries were not reported to us on the NAV forms. These injuries are therefore recorded on the basis of information received in connection with the quality assurance of the data. The injuries not reported on NAV forms also include serious injuries.

In 2016, the injury rate on production facilities fell from 7.3 to 6.1 injuries per million working hours. This is nearly a halving relative to 2007. There are large variations from year to year for some areas of activity. The number of working hours fell by 2.4 million hours, from 26.5 million in 2015 to 24.1 million in 2016.

As on production facilities, mobile facilities have also seen a positive long-term trend. Comparing the rate in 2016 with 2007 (13.5), the 2016 injury rate is just under one third of the level in 2007. The injury rate in 2016 remains at the same level as 2015, at 4.2 per million working hours. There was a considerable reduction in the activity level on mobile facilities from 2015 to 2016. The number of hours fell by 4.6 million hours, from 15.3 million in 2015 to 10.7 million in 2016.

7.1 Serious personal injuries, production facilities

Figur 28 shows the frequency of serious personal injuries on production facilities per million working hours. For the period, we can see that the level in the early part of the decade is higher than in the latter part. Since 2009 there was a declining trend right up to 2013. In 2013, the injury rate on production facilities was at its lowest level (0.4). In the two subsequent years, there was an increasing trend before it again fell to 0.5 per million working hours in 2016. The level in 2016 is not significantly lower than the average in the preceding ten-year period. There were 11 serious personal injuries on production facilities in 2016.

Contractor employees dominate the statistics for serious personal injuries on production facilities for the year. The rate for serious personal injuries per million working hours for contractor employees was more than three times greater than for operator employees. 56% of the total number of working hours on production facilities were performed by contractor employees in 2016.

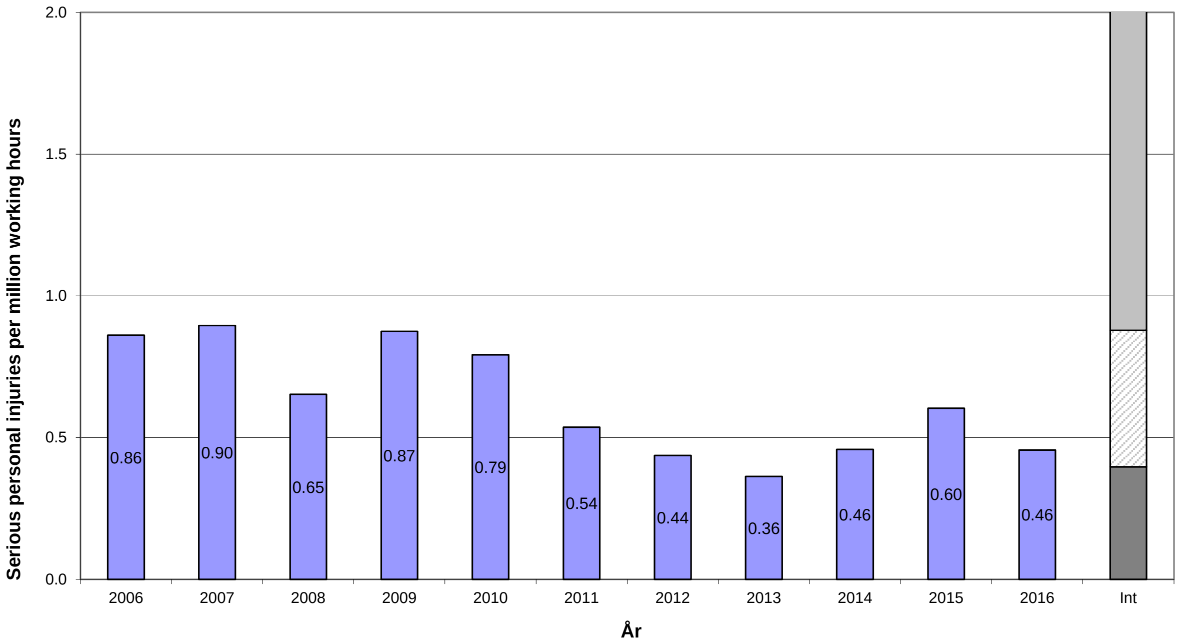


Figure 28 Serious personal injuries on production facilities relative to working hours

7.2 Serious personal injuries, mobile facilities

Figur 29 shows the frequency of serious personal injuries per million working hours on mobile facilities. We have had a marked fall in recent years compared with 2006. Since 2008, we can see a very positive trend and observe the lowest level ever in 2010. From 2012, we once again see a rising trend in the following years, but in 2016 there is a marked reduction in the rate of serious personal injuries of 0.4 injuries per million working hours to 0.5 per million working hours. The injury rate is therefore within the expected values based on the preceding ten years. There were five serious personal injuries in 2016 on mobile facilities.

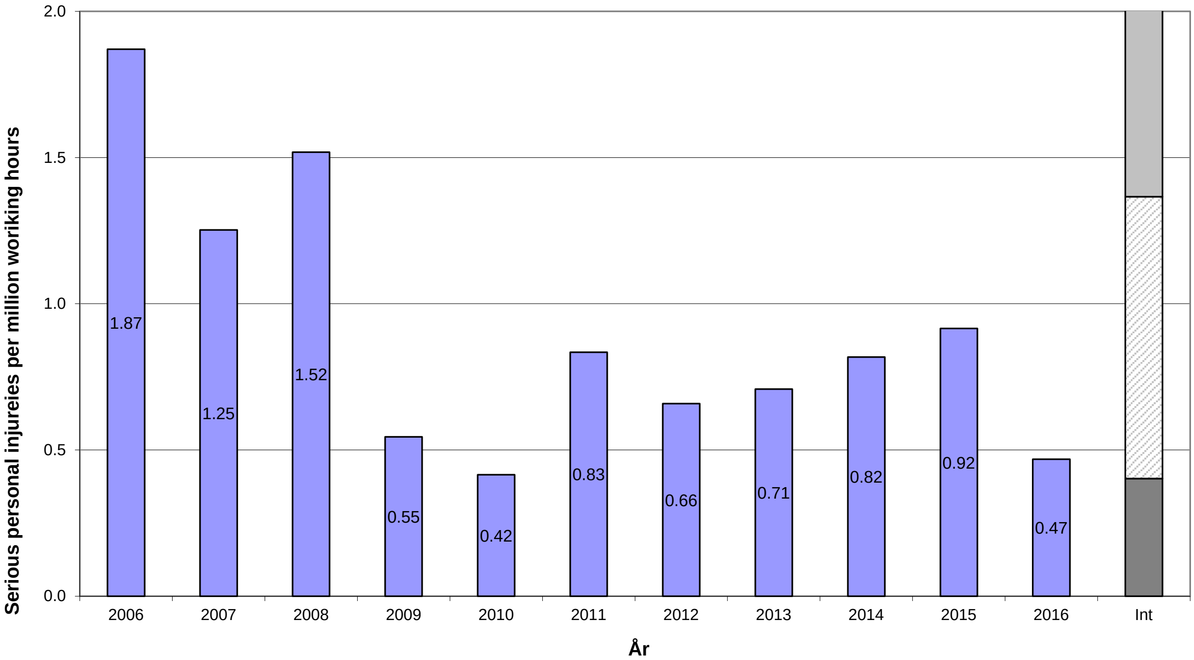


Figure 29 Serious personal injuries per million working hours, mobile facilities

8. Changed risk conditions

The petroleum industry is characterised by extensive and rapid changes, controlled in particular by variations in the oil price. There may be several rounds of downsizings, reorganisations and mergers, and major changes take place in parallel in many areas of the companies. Both in the industry itself and among the authorities, there is concern and uncertainty about the effect of these changes on the HSE risk.

Every two years, a questionnaire-based survey is conducted under the auspices of RNNP among all personnel working on petroleum facilities offshore and at petroleum installations onshore. In 2016, the main results of the questionnaire survey conducted in October-November 2015 were described in the RNNP reports for onshore installations and offshore facilities respectively. In 2015, reorganisation and downsizing processes had been taking place at onshore installations for a while, while the change processes on offshore petroleum facilities were in the initial phase. In this study, data from previous years' surveys will be further analysed with the aim of highlighting the impacyt of the downsizing and reorganisation processes on employee experience of the psychosocial working environment, safety , injuries and.

The purpose of the study in 2016 was to investigate further if any changes in the petroleum industry as a whole and in different groups of employees had occurred in the psychosocial working environment, in the safety climate and in the level of self-reported health complaints and injuries, in this period of considerably increased reorganisation/downsizing.

We also investigated whether employees who experienced downsizing and reorganisation in 2015 report differently on the indicators that measure psychosocial working environment, safety climate, the risk of injury, sickness absence and health complaints compared with employees who do not report such changes. Finally, we investigated whether differences in psychosocial working environment and safety climate help explain any relationship between downsizing/reorganisation and the risk of occupational accidents.

8.1 Literature search

A literature search was performed in the Medline database for the period 1990 to October 2016 in order to summarise research on downsizing, reorganisation and their relationship with health, sickness absence and injury. The review concludes that there is insufficient evidence for an association between reorganisation andpsychological distress, but a number of studies of downsizing report an increased risk of psychological distress and increased use of psychotropic drugs among employees. There were nostudies addressing the direct relationships between downsizing and occupational injuries, and few studies addressed somatic health complaints and general subjective health complaints. Some studies of downsizing and sickness absence report that downsizing leads to increased long-term sickness absence among remaining employees, whereas the effect on short-term sickness absence appears to be in the opposite direction. The literature provides fairly unambiguous support for the fact that losing one's job increase the likelihood of receiving health-related benefits beyond sick pay and for disability pension. At the same time, underlying factors such as the general labour market situation, the nature of the industries affected and the characteristics of the employees involvedcan affect the consequences observed in relation to downsizing processes.

8.2 Sample and methodology

The RNNP questionnaire-based survey is conducted as a cross-sectional study every other year, for the first time in 2001 and most recently in 2015. Answers from all the years that the survey has been conducted comprise the dataset, but the main analyses in our study are based on data from the two last offshore surveys in 2013 and 2015, and the surveys onshore in 2011, 2013 and 2015, i.e. covering the period where the changes processes in the industry accelerated. In spite of a rather low response rate (approx. 30%), from year to year the sample is relatively stable over a range of variables such as gender, age, facility, the area of work, ratio between operators and contractors, permanent and temporary employees and proportion with managerial responsibilities. However, individual changes were observed in the sample in the period 2013-2015, whereby the proportion of temporary employees, contractors and employees on mobile production facilities decreased. This reflects changes observed in the industry in general. The RNNP data provide a good comparative basis for questionnaire analyses from year to year. The large number of s responders in the survey contributes to making the results more robust.

The analyses include three questions that measure, respectively reorganisation, downsizing and job insecurity. Based on the results from a factor analysis described in the RNNP report from 2014, four factors that measure the psychosocial workenvironment were established, andwith support from relevant research literature, three factors that measure the safety climate was included in our analysis. We have examined the following outcome measures: work accident involving personal injury, sickness absence, work-related sickness absence, pains and work-related pains in the neck, shoulder, arm and back, as well as psychological distress. Separate analyses have been performed to look at time trends overall, and for employees on mobile facilities, production facilities and at onshore installations, respectively. Logistic regression analysis was conducted to investigate relationships between downsizing and reorganisation, psychosocial factors, safety climate and injuries.

8.3 Job descriptions/categories

In the RNNP surveys, the respondents were asked to state their job description in a freetext field. The PSA has merged these into 97 job descriptions. In order to provide a description of downsizing, reorganisation, psychosocial working environment, safety climate and health for the different titles, it was necessary to reduce the descriptions further in order to have a sufficient number of observations per job description. They were processed into a final list of 46 job descriptions which we refer to here as job categories.

8.4 Strengths and limitations

A strength of this study is that the questionnaire survey contains questions that cover many background variables that can be seen in connection with downsizing/reorganisation and HSE outcomes. The sample is also large enough to permit analyses of different sub-groups of employees, i.e. employees in different areas of work and job categories, and in risk groups defined in the RNNP report from 2014.

A limitation of the data is, however, that the RNNP questionnaire survey is designed as a cross-sectional survey, i.e. that all information is collected at one and the same time. This limits the ability to draw firm conclusions about relationships observed between exposure (for example, downsizing and reorganisation) and outcomes (for example, sickness absence), and the extent to which exposure precedes outcome (for example, sickness absence) in time. Another important limitation is that those who are absent from work due to sickness, health complaints or injury during the survey are not included in the data. It is also important to point out that studying potential consequences of downsizing or termination of employment is difficult, because those whose employment has been terminated are not included in the data. In other words, those remaining after the downsizing processes are those included in the data.

8.5 Results

Reorganisation and downsizing vary over time, but especially in the period 2013-2015 there has been a considerable increase in the proportion that has experienced reorganisation with moderate or significant importance for how they plan and/or perform their work (from 33% to 49%), and in the proportion who have experienced downsizing or termination of collegues employment in the last year (from 23% to 73%). The percentage of employees who experience great uncertainty related to both current and future job opportunities has also increased significantly over the same period (from 8% to 26%).

8.5.1 Production facilities and mobile facilities

Overall, the psychosocial working environment did not change significantly during the period of ongoing change processes. However, a larger proportion of employees report lower job control on production facilities and higher job demands combined with lower job control on mobile facilities. A higher proportion of employees report a poorer safety climate on production facilities. The changes in the psychosocial working environment on mobile facilities and in the safety climate on production facilities may be potentially related to the ongoing change processes.

During the period from 2013 to 2015, there were no changes in the proportion reporting occupational accidents involving personal injury on production facilities. There was a decrease in the proportion of self-reported injuries on mobile facilities, and the proportion of injuries is at the same level as for operating company employees on production facilities in 2015. The proportion reporting psychological distress and pains in neck/shoulder/arm and back was constant on both facility types. However, the proportion reporting that the distress or pains were wholly or partially caused by the work situation has increased. The self-reported sickness absence was largely unchanged on both facility types. It is important to point out that persons with sickness absence at the time of the survey are not included in the RNNP questionnaire survey, which may have affected the results.

8.5.2 Offshore activity and onshore installations combined

In further analyses, we look more closely at the RNNP questionnaire data from 2015 and perform a series of cross-sectional analyses where we compare employees who have experienced reorganisation/downsizing with those who have experienced such changes to a lesser extent. The results show that employees who report downsizing and reorganisation report higher risk of injuries, a number of health complaints and of sickness absence. At the same time, those who have experienced downsizing or reorganisation report a higher risk of experiencing high job demands, low job control or the combination of high job demands and low job control. Job insecurity is also more frequently reported among those reporting downsizing.

The risk of personal injury is around 50 per cent higher among employees reporting downsizing/reorganisation compared to employees not reporting such changes. In the analyses, we, therefore, wanted to evaluate how much of the increased risk of injury among those reporting downsizing/reorganisation could be explained by psychosocial factors and lower safety climate. The results of the analyses indicate that a significant part of the increased risk of injury may be due to higher job demands and lower job control combined with a poorer safety climate among those who have experienced downsizing/reorganisation.

8.6 Conclusions

There have been some changes in offshore activities related to the psychosocial working environment and safety climate in the period 2013-2015. A larger proprtion of employees on mobile facilities report high job demands and low job control and the combination tof the two factors. On production facilities a larger proportion of employees report low job control and a poorer safety climate. This may be viewed in the context of the ongoing change processes. The level of self-reported work accidents involving personal injury, health complaints and sickness absence was fairly constant during the period.

The analyses of the last questionnaire-based survey in 2015 show, however, that employees who have experienced reorganisation and downsizing report higher risk of injury, sickness absence, health complaints and a poorer safety climate and psychosocial working environment compared with employees who do not report such changes. The analyses indicate that the higher risk of occupational injury reported by those affected by downsizing and reorganisation in the industry as a whole may be associated with a poorer safety climate and psychosocial working environment.

9. Other indicators

9.1 DFU20 Crane and lifting operations

DFU20, concerning crane and lifting operations, covers incidents involving lifting equipment and its use which lead to personal injury or harm to equipment or the environment. This was created and presented for the first time in the 2015 report. This was done to increase the utility of the information that in previous years had been reported under DFU21 falling objects. The time series for DFU20 consists of data from only four years, 2013 to 2016. The analysis focuses both on the four years combined and a comparison between the years, as appropriate. The new DFU has still not been fully incorporated by all the operators, which means that there is some uncertainty concerning the distribution of data received.

There are two new features in this year's report.

- There is a **distinction between fixed and mobile facilities** where the data supports this. Where no differences have been found between them, this is noted in the text and the facility types are presented together. This is in order to ensure data quality.
- **Normalisation of the data** has been introduced so that account of the activity level is taken when data are compared between the years. This has been done by normalising the data against the number of working hours for **drilling and well operations** and the number of working hours for **construction and maintenance**.

The assessment of DFU20 includes assessments of personal injury, types of lifting equipment, work processes, injury/harm potential, and underlying and proximate causes. The processing of the reported incidents shows that a distinction should be made between the following two types of incident:

1. Incidents linked to crane and lifting operations that involve falling objects as a consequence of a lifting operation. Where information about weight and drop height are stated, these incidents are categorised in accordance with their energy potential.
2. Incidents linked to crane and lifting operations that do not involve falling objects, or where there is a lack of data about weight and drop height. These incidents have the potential for injury (e.g. swinging loads that cause crushing injuries), and they are therefore categorised under Synergi categories (only yellow and red incidents). This type of incident has not previously been part of RNNP. The objective is to be able to evaluate causal factors and perform closer assessments of the most serious incidents, even if falling objects are not involved.

An analysis was conducted to categorise the incidents in accordance with *underlying* and *proximate* causes Categories were defined in accordance with the category model developed in the BORA project; see the main report. This method was originally developed to classify hydrocarbon leaks, but has been generalised and adapted for use on incidents involving crane and lifting operations. See the main report for a presentation of the assessments of causal factors.

Figur 30 shows the number of reported incidents in the period 2013-2016. The figure shows fixed and mobile facilities, and both absolute and normalised numbers. The normalisation has been done by showing the number of incidents per million working hours in total per type of facility, i.e. both number of working hours relating to drilling and well operations and the number of working hours relating to construction and maintenance.

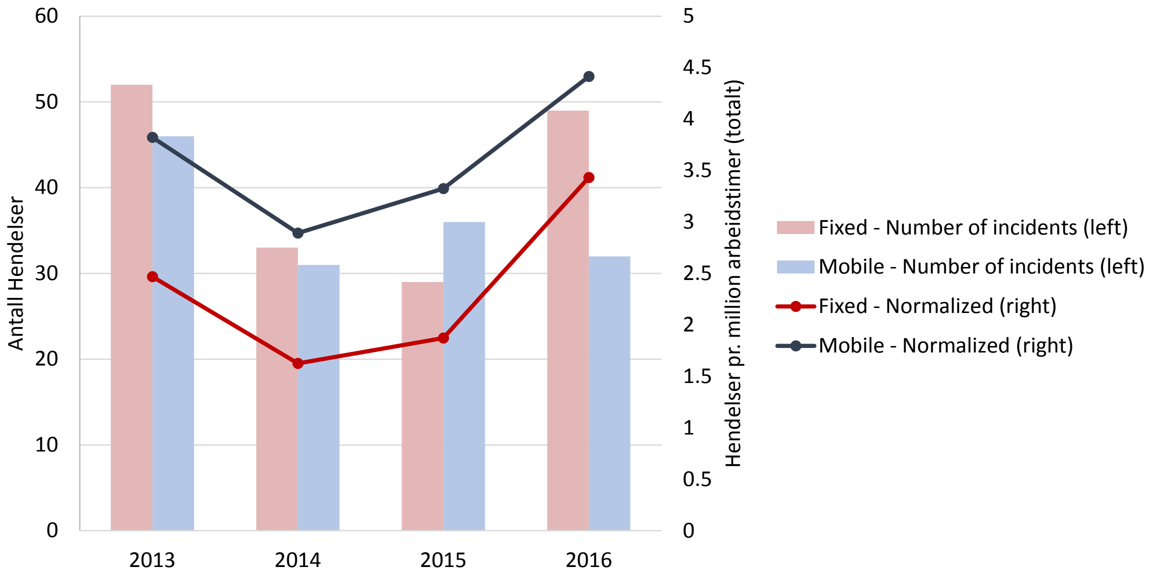


Figure 30 Number of reported incidents for crane and lifting operations in the period 2013-2016 for fixed and mobile facilities – absolute numbers and numbers normalised against millions of working hours relative to drilling and well operations and to construction and maintenance, per type of facility

The total number of incidents[3] for 2013 (N=101) is considerably higher than for 2014 (N=64) and 2015 (N=67). For 2016, the total number of incidents (N=81) is higher than in 2014 and 2015 (increase for fixed facilities, while appearing to have levelled out for mobile facilities). This may give the impression that the fall in the number of incidents has stabilised for mobile facilities, but examining the normalised number of incidents shows that, since 2014, there has been an increasing number of incidents per million working hours, for both fixed and mobile facilities. Incident data in the same format as in the period 2013-2016 are not available for the period prior to 2013.

Figur 31 shows the number of reported incidents involving personal injury for 2013-2016 for fixed and mobile facilities with both absolute and normalised numbers. The normalisation has been done by showing the number of incidents per million working hours in total per type of facility, i.e. both number of working hours relating to drilling and well operations and the number of working hours relating to construction and maintenance.

[3] Includes incidents for fixed and mobile facilities, and a very few incidents where it was not possible to determine the type of facility.

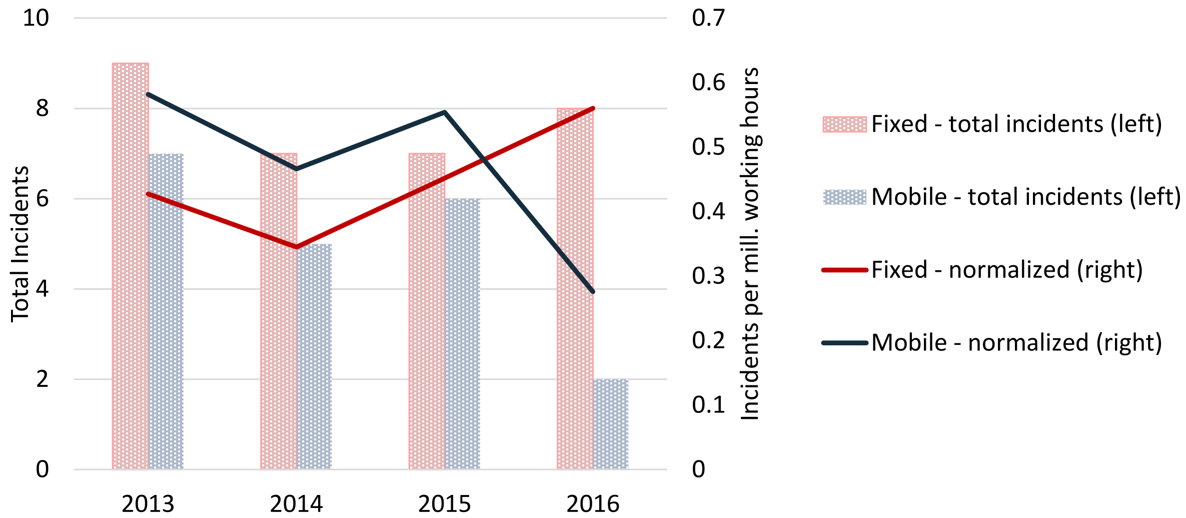


Figure 31 Number of personal injuries for crane and lifting operations in the period 2013-2016 for fixed and mobile facilities – absolute numbers and numbers normalised against millions of working hours relative to drilling and well operations and to construction and maintenance, per type of facility

Of the total 313 reported incidents for the period 2013-2016, 51 of the incidents caused personal injury. How these break down by year and facility type is summarised in Tabell 3.

Table 3 Total number of reported incidents, and incidents involving personal injuries by facility type

Year	*Total number of reported incidents*	*Number of incidents involving personal injuries*	
		Fixed facilities	*Mobile facilities*
2013	101	9	7
2014	64	7	5
2015	67	7	6
2016	81	8	2

There is a relatively low number of incidents involving personal injury (16% of reported incidents): a total of 51 incidents for all years/both facility types. One must therefore exercise caution in breaking the data down further into types of facility and so forth.

When the number of incidents involving personal injury is normalised against the number of working hours, it can be seen from Figur 31 that there is a fall for both fixed and mobile facilities from 2013 to 2014, but an increase to 2015. For mobile facilities, the number per million working hours falls again in 2016. In contrast to the mobile facilities, the number per million working hours for fixed facilities shows a marked increase from 2015 to 2016. The absolute number of incidents involving personal injury also increases for fixed facilities from 2015 to 2016.

9.2 DFU21 Falling objects

DFU21 Falling objects comprises incidents where an object falls more than zero metres within a facility's safety zone, either on deck or into the sea, with the potential for becoming an accident, and which does not involve crane and lifting equipment and the use thereof.

The assessment of DFU21 includes an assessment of manning, work process involved, energy (weight combined with drop height). Incidents linked to crane and lifting equipment and the use thereof are presented in DFU20.

As of the 2015 report for offshore facilities, a new DFU20, Crane and lifting operations, was introduced which has caused changes in DFU21 Falling objects. The time series now consists of data for the period 2013-2015. The analysis looks at both the four years combined and a comparison between the years, as appropriate.

There are two new features in this year's report.

- There is a **distinction between fixed and mobile facilities** where the data supports this. Where no differences have been found between them, this is noted in the text and the facility types are presented together. This is in order to ensure data quality.
- **Normalisation of the data** has been introduced so that account of the activity level is taken when data are compared between the years. This has been done by normalising the data against the number of working hours for drilling and well operations and the number of working hours for construction and maintenance. A description of which of these normalisation data are employed is provided in conjunction with the individual figures.

As described above, the normalisation is performed against the number of working hours for **drilling and well operations** and for **construction and maintenance**. A description of which of these normalisation data (just one or both categories) are employed is provided in conjunction with the individual figures. In addition to working hours for these two categories, there is equivalent categorisation for **catering** and **administration**. However, it is assessed that the most accurate normalisation will be achieved by not including these last two categories, since we are looking for an expression of the general activity level for relevant work processes (described in the main report).

The assessment of DFU21 includes an assessment of exposed personnel (including number of persons injured and manning in the area), work processes involved, energy (weight combined with drop height) and potential for an HC leak.

Once incident may cause several falling objects and for DFU21 it is relevant to count the number of falling objects.

Figur 32 shows the number of reported incidents in the period 2013-2016 broken down by fixed and mobile facilities. Total and normalised numbers of incidents are shown. The normalisation has been done by showing the number of incidents per million working hours in total per type of facility, i.e. both number of working hours relating to drilling and well operations and the number of working hours relating to construction and maintenance.

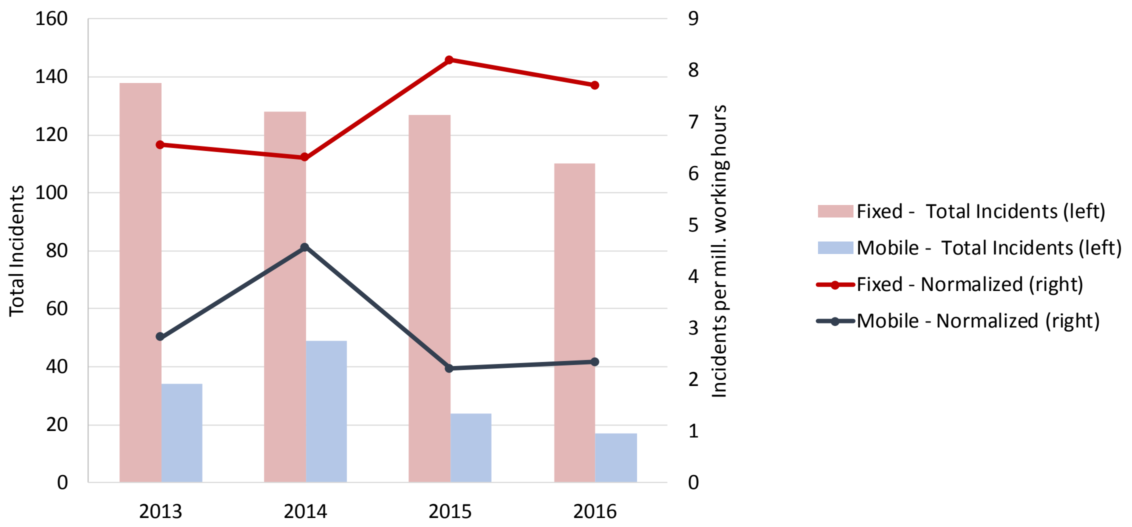


Figure 32 Number of incidents and incidents per million working hours classified as falling objects, by fixed and mobile facilities, in the period 2013-2016.

For the period 2002-2014, when DFU21 Falling objects also included incidents now comprised by DFU20 Crane and lifting operations, the total number of incidents declined slightly. A further fall was observed in the period 2013-2016 for fixed facilities. For mobile facilities, there was an increase in the number of incidents from 2013 to 2014, but here too there was a fall in the number of incidents in the last three years.

The picture looks different when considering the number of incidents per million working hours. For both fixed and mobile facilities, there is an absence of clear trends.

Figur 33 shows the total number of falling object incidents causing personal injury, in the period 2013-2016, a total of 13 incidents. The data show that all of these incidents are from fixed facilities.

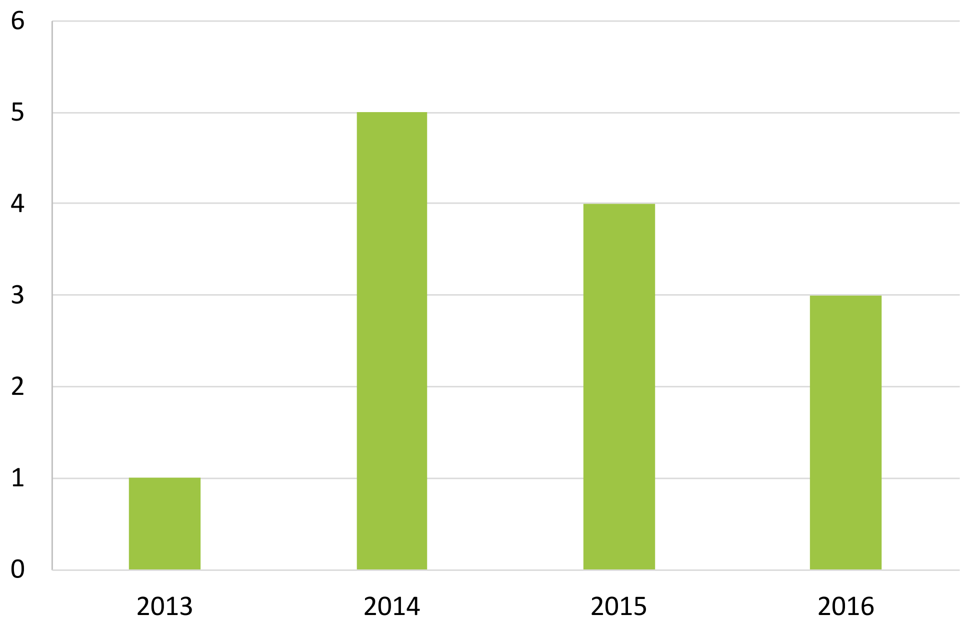


Figure 33 Total number of falling object incidents causing personal injury, in the period 2013-2016.

Figur 34 shows the total number of incidents involving falling objects and personal injuries by main category of work process, in the period 2013-2016. As for Figur 33, all of the total of 13 incidents involving personal injury derive from fixed facilities. More than half of the incidents are linked to the "scaffolding" work process, around one third are linked to "other areas", and the remainder to drilling areas. There were no incidents involving personal injury in process areas.

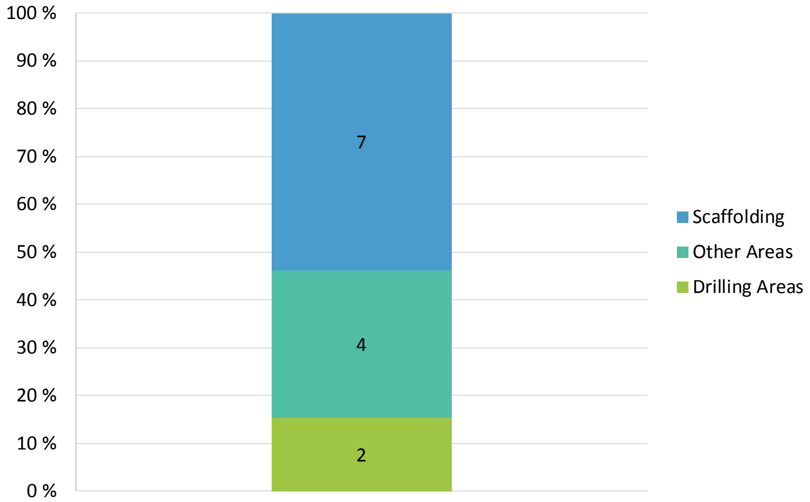


Figure 34 Total number of incidents with falling objects and personal injuries by main category of work process (number of incidents is given in the column), in the period 2013-2016.

For work processes relating to scaffolding, the contribution from the mobile facilities is effectively negligible. We therefore only look at work processes relating to scaffolding on fixed facilities, disregarding incidents from scaffolding not in active use or undergoing erection/dismantling. Figur 35 shows that there is a steady increase in the number of incidents relating to erection/dismantling and use of scaffolding, with a provisional peak of 16 incidents in 2016. The normalised data (incidents per million working hours relating to construction and maintenance) also show an increase, from 0.6 in 2013 to 1.6 in 2016.

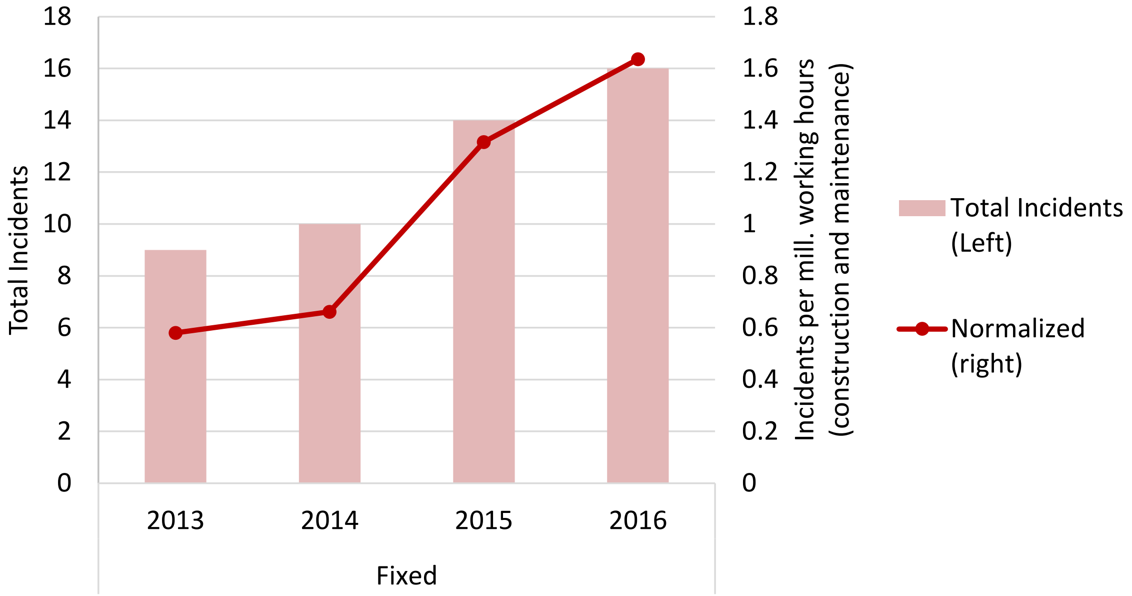


Figure 35 Number of incidents on fixed facilities linked to erection/dismantling and use of scaffolding, and normalised against working hours for construction and maintenance, for the period 2013-2016.

9.3 Other DFUs

The main report presents data for incidents that have been reported to the Petroleum Safety Authority Norway, as well as for other DFUs without major accident potential, such as DFU11, 13, 16 and 19, see Tabell 1.

10. Definitions and abbreviations

10.1 Definitions

See sub-chapters 1.10.1 - 1.10.3, as well as 4.2, in the main report.

10.2 Abbreviations

For a detailed list of abbreviations, see PSA, 2017a. Trends in the risk level on the Norwegian Continental Shelf, Main report, 27/04/2017. The most important abbreviations in this report are:

CODAM	Database for damage to structures and subsea facilities
BDV	Blowdown valve
DDRS/CDRS	Database for drilling and well operations
DFU	Defined hazard and accident situations
DHSV	Downhole safety valve
ESDV	Emergency shutdown valve
PM	Preventive maintenance
GM	Metacentre height of floating facilities
HSE	Health, safety and environment
KG	The distance from the keel to the centre of gravity on floating facilities
KPI	Key Performance Indicator
CM	Corrective maintenance
PSA	Petroleum Safety Authority Norway
STAMI	National Institute of Occupational Health
WIF	Well Integrity Forum

11. References

Detailed reference lists can be found in the main reports:

PSA, 2017a. Trends in the risk level on the Norwegian Continental Shelf, Main report, 27/04/2017
PSA, 2017b. Trends in the risk level – onshore facilities in the Norwegian petroleum activities, 27/04/2017
PSA, 2017c. Trends in the risk level on the Norwegian Continental Shelf, Methodological report, 27/04/2017