

TRENDS IN RISKS

**TRENDS IN RISK LEVEL
IN THE PETROLEUM ACTIVITY
SUMMARY REPORT 2015
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. The first RNNP report concerning acute spills to sea was published in 2010. 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 Due to the data collection period in EPIM, the RNNP report on acute spills will not be published until autumn.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, 28 April 2016

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Part 1: Objective and conclusions

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 for activities on the Norwegian Continental Shelf (NCS).

The industry has traditionally used a selection of indicators to illustrate safety trends in the petroleum activities. The use of indicators based on the frequency of lost-time incidents has been particularly widespread. It is generally accepted that this only covers a small part of the overall safety picture. There has been a development in the industry in recent years where multiple indicators are used to measure trends in a few key HSE factors. For the parties in the industry, it is important to establish a procedure for measuring the impact of the industry's overall safety work.

The Petroleum Safety Authority Norway wishes to create a relevant profile of the risk level based on a set of complementary information and data from multiple sides of the industry, to permit measurement of the impact of the overall safety work in the activities, as this report seeks to do.

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 unwanted 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 focus is personal risk, which here includes major accidents, occupational accidents and working environment factors. Both qualitative and quantitative indicators are used. The year's report also includes results from the questionnaire-based survey performed under the auspices of RNNP every other year.

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

- All production and mobile facilities on the NCS, including subsea facilities.
- Passenger transport by helicopter, from departure/arrival from helicopter terminals to landing/departure at the facilities.
- Use of vessels within the safety zone around the facilities.

Onshore facilities in the PSA's administrative area are included as of 1 January 2006. Data collection started from this date, and separate reports have been published since then. Outcomes and analyses for onshore facilities and the results from these facilities are not included in this summary report. Since 2010, an annual report has been published with a

focus on acute spills to sea from offshore petroleum activities. The next report concerning acute spills is expected during the autumn of 2016.

2. Conclusions

The PSA seeks to measure progress in safety, the working environment and the external environment using a series of indicators. The basis for the evaluation is the triangulation principle, i.e. assessing developments by using several instruments to measure changes in risk level.

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.

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
- Risk factors in the working environment:
 - Noise exposure harmful to hearing
 - Chemical working environment
 - Ergonomic factors
- HSE work and the state of HSE using a questionnaire-based survey

In 2015, for the eighth time, a questionnaire-based survey was conducted among personnel working on the Norwegian Continental Shelf (NCS). This survey has been conducted every other year since 2001. Even though the questionnaire is being continuously developed, the core of the survey remains the same. This provides unique data, with opportunities for studying different facets of the state of HSE on the NCS and their trends over time.

For 2015, the composition of the respondents to the questionnaire-based survey changed somewhat since the previous occasion. This is due in particular to an increase in the proportion of operators' employees and of employees on production facilities, and a decrease in the proportion of contractors' employees and of employees on mobile facilities. There was also a higher proportion of employees reporting reorganisations and downsizing. It is important to take these changes into consideration when reading the results in this report.

The results from the questionnaire-based survey presented in the report provide an overall picture of the employees' assessment of occupational health and safety in the workplace. The overall assessment is that, in some areas, the HSE climate has developed negatively. We see a negative trend in variables that indicate that the prioritisation of HSE is not being evaluated as highly this year as at the time of previous measurements in 2013. Among other things, there is weaker affirmation of the adequacy of manning to properly safeguard HSE, and stronger affirmation of the prioritisation of production concerns over HSE concerns, relative to 2013.

In spite of the negative changes in the HSE climate, perceived risk does not appear to have particularly increased since 2013.

A significant negative development is seen in perceived exposure to chemicals, as concerns both skin contact and what is seen or smelt. In other respects, the physical, chemical and ergonomic working environment does not appear to have changed negatively compared with 2013. There is a positive trend in perceived indoor climate, stressful overtime work, and rest and relaxation between work periods and work days.

The psycho-social working environment appears however to have turned negative between 2013 and 2015. This concerns in particular the pace of work and the potential for influencing it. There is also a negative trend in the variable "Can you influence decisions that are important for your work?" and in the availability of support and assistance from immediate managers. Overall, the results point to a more challenging psycho-social working environment, with increased demands and less control.

Among health complaints, the commonest reports are of pains in the neck, shoulders or arms, back or knees/hips. We are seeing a significant increase in complaints of tinnitus. This is also the health complaint that most people believe is job-related. The vast majority assess their ability to work as good, in respect of both physical and mental demands.

In 2015, ten hydrocarbon leaks exceeding 0.1 kg/s were recorded. This is the highest number recorded since 2011. Of these, four leaks were in the category of 1-10 kg/s in 2015. The other six leaks were between 0.1 and 1 kg/s. The contribution to the total indicator in 2015 is among the highest in years without leaks exceeding 10 kg/s. The relatively high contribution derives from two incidents in 2015 of 6.9 kg/s and 8 kg/s, which are in the upper echelon of the 1-10 kg/s category.

15 well control incidents were recorded in 2015, 12 in the lowest risk category (level 3) and three in the medium risk category (level 2). There were no incidents in the high severity category. The frequency of well control incidents in exploration drilling shows large annual variations. There was a halving of the levels between 2014 and 2015. The number of well control incidents per 100 production wells has been at a stable level for the last five years, without any sign of improvement. However, it is emphasised that the level in the last five years is lower than in the preceding period. The risk indicator for exploration drilling rose in 2015 compared with 2014 and corresponds to the upper level of the period 2007-2014. The risk indicator for production drilling has been at a stable level for the last five years. There were ten well incidents relating to production drilling in 2015, all of low severity (Level 3).

Five ships on collision courses were recorded in 2015, a small increase over 2014. Assessed against the number of facilities monitored from Sandsli, a significantly lower level was observed compared with the period 2005-2014. We can see that sea areas around the facilities being controlled from dedicated traffic centres has had an effect.

One incident concerning a large drifting object was recorded in 2015. A failure in the tow of a barge in the southern North Sea led to the barge drifting northwards towards the facilities in the southern fields and caused demanning and downmanning of a number of facilities on the NCS. In relation to the potential for loss of life, in this situation there was relatively ample time to evacuate crews on board the facilities that were at risk of being hit by the barge.

In 2015, there was one collision between a facility and field-related vessel (supply vessel). This number is at the same level as the average of recent years. None of the collisions in the last four years has been in the severe category.

In 2015, there were seven incidents relating to structures and maritime systems. One of the incidents concerned DP systems, four were cracks in main load-bearing structures, one involved flooding, and there was one serious incident on a mobile facility where a wave stove in windows in the accommodation section. In this last-mentioned incident, one person died and four were injured.

One leaks from a riser to a manned production facility was reported in 2015. There were four reported incidents of serious damage to pipelines and risers in 2015. Flexible risers continue to dominate the risk scenario.

The other indicators reflecting near-misses with major accident potential show a stable level with relatively minor changes from 2014 to 2015.

The total indicator which reflects the potential for loss of life if registered near-misses develop into actual incidents is a product of the number of registered incidents and 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 this type of indicator therefore provides 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 2015 is higher than in 2013 and 2014, but not significantly higher in comparison with the period 2005-2014. One quarter of the risk contribution is from the wave which stove in a window on a facility, causing a fatality, and another quarter is from damage and leaks on risers to production facilities. When there are few incidents in total, the total indicator is sensitive to individual incidents with a large potential for causing loss of life.

Helicopter risk constitutes a large share of the overall risk exposure to which employees on the NCS are exposed. 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 incidents. The expert group consists of personnel with pilot, technical, ATM and risk expertise.

The indicator which reflects the most serious incidents and which is being assessed by the expert group shows a further decline in the number of incidents from 2014 to 2015. None of the incidents in 2015 were assessed by the expert group as having "little remaining safety margin" or "medium remaining safety margin". One incident in 2014 was assessed as having had "little remaining safety margin", whereas in the five preceding years only incidents with "medium remaining safety margin" were recorded.

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 reveal that there are large differences between the facilities. Some facilities affect the failure rate more than others, but the industry nonetheless has clear improvement potential for a number of the barriers. A comparison has been made with industry standards since 2011 and, except for deluge valves, there is no overall clear tendency for those barrier elements which are above the industry standard to come down towards it. Taking into account the industry's focus in recent years on major accident prevention, one would expect it to be possible to achieve greater improvements in this area than are shown by data from the period.

Maintenance management data have been collected for more than five years. The data for the production facilities show a clear reduction in 2015 in the total backlog of preventive maintenance, both for HSE-critical equipment and equipment in general. The figures for 2015 are the lowest since reporting began in 2010. At the same time, we see that hours of preventive maintenance performed increased in the period 2011-2015. Total outstanding HSE-critical corrective maintenance shows a clear reduction in 2015 compared with the previous years. Concerning the total volume of corrective maintenance for production facilities, the figures show that a few facilities have identified a considerable number of hours of work required, compared with the median for all the facilities.

The data for maintenance management on mobile facilities show an increase for some facilities in terms of the number of tagged and classified pieces of equipment. In other respects, the 2015 situation is unchanged from previous years.

There was one fatal accident within the PSA's area of authority on the NCS in 2015. This occurred on 30.12.2015 on COSL Innovator during a storm. A large wave hit the facility and caused considerable damage to the accommodation module. One person died and four were injured.

In the long term, over the period 2005 to 2013, there has been a downward trend in the frequency of serious personal injuries relative to the peak in 2005. The injury rate was at its lowest (0.48) in 2013. However, the last two years have seen an increase in the rate and, in 2015, we have recorded 0.72 serious personal injuries per million hours worked against 0.58 in 2014. The frequency is within the expected level based on the ten preceding years. Compared with contractors' employees, operators' employees now dominate the injury rate on production facilities. This group had no serious injuries in 2014, but in 2015, this picture has changed, with a rate of 0.95 which stands out negatively in relation to the four preceding years. Contractors' employees on production facilities showed a positive trend in 2015 (0.38) compared with the level in 2014 (0.69). Since 2013, the injury rate on mobile facilities shows a rising tendency, and in 2015 the rate was 0.92 serious personal injuries per million working hours.

The noise indicator shows an improvement for eight out of eleven position categories from 2014 to 2015. The position categories of mechanics, assistants and cementers show a slight worsening. Most groups show a weak, but relatively even, improvement over the decade. Most of the position categories covered by this survey are subject to noise exposure above the threshold value of 83 dBA. The noise indicator for the position categories of machinist and surface treatment personnel are considerably higher than for other groups and for this group, the noise indicator including ear protection is relatively high.

The industry project for noise reduction in the petroleum activities that was initiated in 2011 is expected to contribute towards improvement in the noise indicator over time. Based on recent years' results, this work has not produced a significant impact.

The indicator for the chemical spectrum's hazard profile shows that there is still considerable variation between facilities with regard to the number of chemicals in use. To a certain degree, the variation reflects the type of facility and activities on the facility. Production facilities generally have a higher number of chemicals in circulation than mobile facilities.

There has been a negative development in the number of chemicals in use on both production and mobile facilities. For production facilities, there is a marked increase from 2014 to 2015 in the number of chemicals with health-hazard classification and the number of chemicals with high risk potential. The indicator that describes risk factors associated with chemical exposure for position categories shows that short-term assessments for mechanics and process operators are highest for production facilities, and shaker operators' short-term assessments and surface treatment personnel's short-term assessments are highest for mobile facilities.

Indicators for ergonomics show that the positive trend seen last year for most of the groups on production facilities has flattened out, and to some extent reversed. Here it is only surface treatment personnel who show a clear reduction in the proportion of work tasks assessed as red. Compared with 2013 however, the reduction is not so large. For the other groups, the proportion of red work tasks is at roughly the same level as in the year before. For roughnecks, catering assistants and mechanics, there was a slight increase, and for scaffolders and process operators a slight decrease. Roughnecks are the group which, in 2015, had the most work tasks assessed as red.

For mobile facilities, the beneficial trend from 2014 and, to an extent 2013 and 2012, continues, with a reduction in the share of work tasks assessed as red in 2015. Here too roughnecks are the group with the most red overall assessments of work tasks.

It is working position and lifting which prove to be the stress factors that contribute most negatively for roughnecks, both for production facilities and mobile facilities. Compared with 2014, there has been an increase in red overall assessments for working position for roughnecks.

Working position is the factor which contributes most for the groups of mechanics and surface treatment personnel. For surface treatment personnel, handheld tools also contribute strongly. For scaffolders, working position and lifting are the most prominent factors.

"Late life safety" is one of the PSA's main priorities. This prioritisation is based on the premise that regulatory requirements and prudent activities may more readily come under pressure in late life, and that it may be more difficult to sustain and improve the HSE level during this phase.

In the autumn of 2015, we commissioned a study based on the hypothesis that the HSE level is weakened on late life facilities. The remit of the study was to investigate trends and patterns in the data collected through RNNP, including major accidents (DFUs), noise exposure harmful to hearing, personal injuries, acute spills, barriers against major accidents, maintenance and questionnaire data.

The study showed that around one third of the facilities on the NCS can be seen as being in their late life to one degree or another. The transition to late life occurs gradually, and it is difficult to define exactly when it happens.

The study also showed that the data provide little support for the hypothesis that HSE conditions are poorer on late life facilities compared with newer facilities. Nor do the interviews performed support such a correlation.

For some barriers, especially valves, we see a tendency for an increased failure rate on late life facilities. Within maintenance, we see that both the total volume of maintenance and backlog of maintenance increase. In interviews, it emerged that late life facilities may make operational and maintenance-related changes that can potentially affect regularity and non-critical systems. However, such changes will only be made following careful assessment and without being at the cost of safety.

In general, it appears that late life facilities are able to maintain their safety levels.

Overall assessment

There was one fatality in the petroleum activities in 2015. The previous fatality to that was in 2009. Over a number of years, a variety of indicators in RNNP have shown positive trends, and overall the level within many areas has been notably better in recent years than in the period 8 to 10 years ago.

The results from 2015 show that some conditions have moved in a negative direction since 2014. Although annual changes in the type of indicators used in RNNP are to be expected, it is surprising that this negative trend appears so widespread, given the industry's stated focus on improving HSE conditions.

Part 2: Execution and scope

3. Execution

The work in 2016 is a continuation of previous years' activities, carried out in the period 2000-2015; see NPD (2001), NPD (2002), NPD (2003), PSA (2004), PSA (2005), PSA (2006), PSA (2007), PSA (2008), PSA (2009), PSA (2010), PSA (2011), PSA (2012), PSA (2013), PSA (2014) and PSA (2015). (Complete references are provided in the main report, as well as at www.ptil.no/rnnp). This year we have continued the general principles and have further developed the reporting. 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.
- Performance of an analysis of "RNNP data in a late life perspective".
- Performance of a questionnaire-based survey.
- A considerable volume of empirical data on barriers against major accidents was collected and analysed in the same way as in the period 2003-2014. Greater emphasis has been placed on nuances in the data for well barriers and BOP.
- Indicators for noise, chemical working environment and ergonomics have been continued.
- Data from onshore facilities have been analysed and presented in a separate report.
- Acute spills to sea and potential spills to sea are undergoing analysis, and will be presented in a separate report.

3.1 Execution of the work

The work on this year's report began in January 2016. 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, as well as in the work on adapting the model for onshore facilities, which have been included as of 1 January 2006 |
| • Helicopter operators: | Contribute data and information about helicopter transport activities |
| • HSE discipline 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, Robert Ekle, Grethe Lillehammer, Torleif Veen, Turid S. Solberg, Trond Stillaug Johansen, Asbjørn Gilberg, Kai Arne Jenssen, Knut-Arne Vik and Arve Olaf Torgauten, Safetec
- Anita Øren, Tony Kråkenes, Øyvind Dahl, Knut Øien, Stein Hauge and Stian Antonsen, SINTEF
- Kathrine Skoland, Kari Kjestveit, Stian Brosvik Bayer and Ida Holth Mathiesen, IRIS
- The PSA's working group consists of: Øyvind Lauridsen, Mette Vintermyr, Arne Kvitrud, 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, Erik Hamremoen, Norwegian Oil and Gas Association, represented by LFE
- Egil Bjelland, Morten Haugseng, Trond Arild Nilsen, CHC Helikopter Service
- Ole Morten Løge, Geir Arne Karlsen, Bristow Norway AS
- Dag Vidar Jensen, Norsk Helikopterservice AS
- Øyvind Øglænd, BlueWay Offshore Norge 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, other fires)
 - Construction-related incidents (i.e. structural damage, collisions, 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
- Work accidents
- Noise, chemical working environment and ergonomics
- 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 it against the incident register and other databases in the Petroleum Safety Authority.

Table 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 Synergy.

3.3 Developments in the activity level

Figure 1 and Figure 2 show the developments over the period from 2000 to 2015 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, 2015a) presents the underlying data in detail.

Table 1 Overview of DFUs and data sources

<i>DFU no.</i>	<i>DFU description</i>	<i>Data sources</i>
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)
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 (precautionary/emergency 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 ₂ S 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.

This is a fall in total working hours for production facilities of around 19% compared with the previous year. Working hours in production in 2015 are therefore on a par with the period 2002-2005. This is a marked reduction, and the total number of working hours in 2015 is around 6% below the average for the period 2000–2014. For mobile facilities, the fall in the total number of working hours is less, with a reduction of around 4% from the previous year. It is also worth noting that, despite a fall in the number of working hours, there is an increase in the numbers of both production wells and exploration wells compared with the previous year.

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.

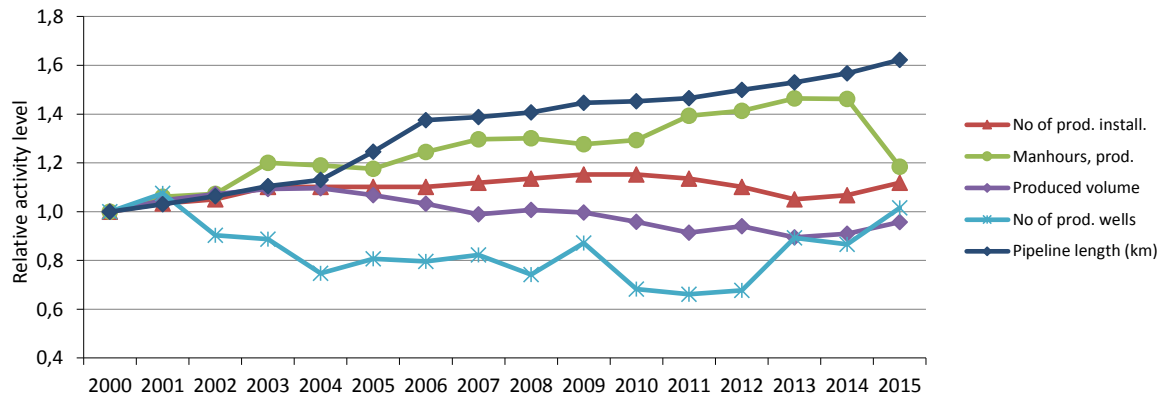


Figure 1 Trend in activity level, production

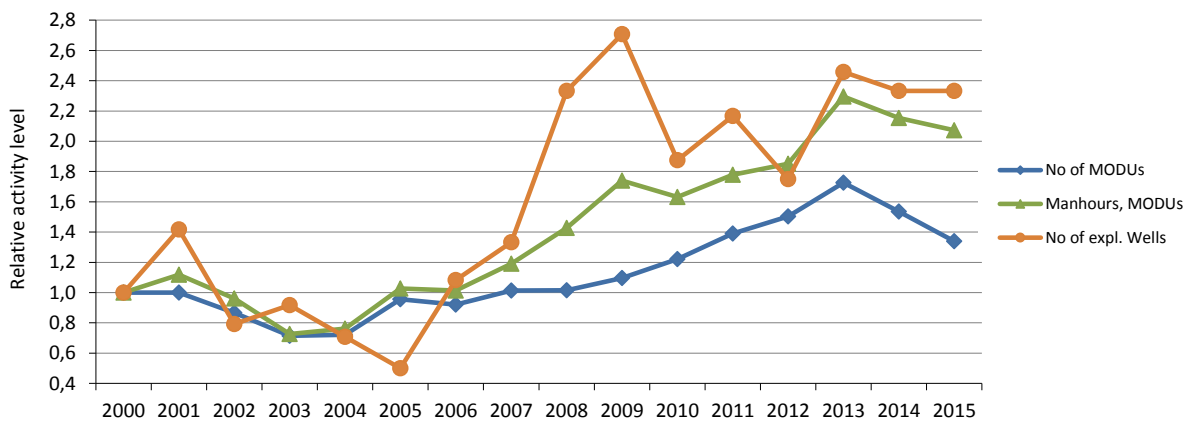


Figure 2 Trend in activity level, exploration

A corresponding activity overview for helicopter transport is shown in sub-chapter 5.1.

3.4 Documentation

Analyses, assessments and results are documented as follows:

- Summary report – the Norwegian Continental Shelf for the year 2015 (Norwegian and English versions)
- Main report – the Norwegian Continental Shelf for the year 2015
- Report for onshore facilities for the year 2015
- Report for acute spills to sea for the Norwegian Continental Shelf 2015, to be published in the autumn of 2016
- Methodological report, 2016

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

4. Survey questionnaire

A questionnaire-based survey was conducted of all personnel who were offshore in the period 12 October to 20 November 2015. At an overarching level, the object of the questionnaire-based survey is to acquire knowledge about employees' perception of the state of HSE in Norwegian petroleum activities. This is the eighth time that such a survey has been conducted on the NCS. The first occasion was in 2001, since when it has been conducted every other year. In parallel with this survey, a similar survey was carried out of petroleum facilities onshore. The results from the onshore facilities are presented in a separate report.

The questionnaire covered the following topics: demographics, the HSE climate, experience of accident risk, recreation conditions, working environment, ability to work, health, sickness absence, sleep, rest, and working hours.

A total of 6,980 people completed the questionnaire. The response rate for this year's survey was 24.4 % for mobile facilities and 32.9 % for production facilities. For the NCS as a whole, the response rate was 29.7 %. The response rate is calculated on the basis of the number of working hours which the companies have reported to the PSA. Although this is a relatively low response rate, the number of replies is nonetheless sufficiently large to permit statistical analyses and to break down the data into different groupings. In order to assess whether the sample is representative of the population, the demographic characteristics of the sample may be examined. There were some changes in the demographic characteristics from 2013 to 2015. These changes appear however to reflect the changes in the petroleum industry in general, where the proportion of contractors and employees on mobile facilities has declined relative to the proportion of operators and employees on production facilities.

4.1 HSE climate

Between 2013 and 2015, we see a change in the HSE climate that points in many areas to a negative trend. The list below shows the statements that had a significant negative trend from an HSE perspective.

More people express their agreement with the following negative statements about HSE:

- In practice, production concerns take precedence over HSE concerns (27.4% agree fully or in part).
- I am sometimes pressured into working in a way that threatens safety (12% agree fully or in part)
- Deficient maintenance has led to poorer safety (41.6% agree fully or in part).
- Career-wise, it is a drawback to be concerned about HSE (14% agree fully or in part)
- Reports on accidents or hazardous situations are often sanitised (28.2% agree fully or in part).
- I experience group pressure which compromises HSE assessments (10.9% agree fully or in part)

More people express their disagreement with the following positive statements about HSE:

- Risky work operations will always be carefully reviewed before they are started (2.3% disagree fully or in part)
- Manning is adequate for properly safeguarding HSE (19.6% disagree fully or in part)
- Input from the safety delegates is taken seriously by the management (10.1% disagree fully or in part)
- I can influence the HSE conditions at my workplace (3.8% disagree fully or in part)
- Information about unwanted incidents is used effectively to prevent recurrence (8.3% disagree fully or in part)
- My manager values me drawing attention to matter of importance for HSE (4.3% disagree fully or in part)
- The company I work for takes HSE seriously (3.7% disagree fully or in part)

- My manager is involved in the HSE work on the facility (3.5% disagree fully or in part)

4.2 Perceived accident risk

In spite of the negative changes in HSE conditions, perceived risk does not appear to have particularly increased since 2013. The only perceived risk that has increased since 2013 relates to sabotage/terror. This year, as in previous years, the employees perceive the highest accident risk to be associated with falling objects, gas leaks and serious occupational accidents. Perceived risk associated with helicopter accidents has declined, which is also reflected in the fact that, throughout the entire RNNP period, the employees express increasing satisfaction with comfort during helicopter transport.

4.3 Working environment

A significant negative development is seen in exposure to chemicals, as concerns both skin contact and what is seen or smelt. In other respects, the physical, chemical and ergonomic working environment does not appear to have changed negatively compared with 2013. There is a positive trend in indoor climate, stressful overtime work, and rest and relaxation between work periods and work days.

In respect of the psycho-social environment, some of the results point in a negative direction compared with 2013. The employees experience a greater obligation to work at a high pace and less ability to determine their own work rate. They also experience less ability to influence key decisions concerning their own work and to get support and assistance from their immediate superior.

4.4 Leisure

The employees are generally satisfied with most of the circumstances relating to rest and recreation offshore. They have also become more satisfied since the previous measurement. This may relate to the fact that a larger proportion of the responses come from production facilities in 2015 than in 2013.

4.5 Health and sickness absence

Most of those who responded to the survey assessed their own health and ability to work in relation to mental and physical requirements as good or very good. They did the same in previous surveys. At the same time, it is apparent that many of the employees have one or more health complaints to one degree or another. As in previous years, the commonest reports of health complaints are of pains in the neck, shoulders, arms, back, knees and hips, and impaired hearing. We are seeing a significant increase in complaints of tinnitus. This is also the health complaint that most people believe is job-related. There were no major changes in sickness absence from 2013 to 2015.

4.6 Comparison of HSE assessments offshore and onshore

The assessments of the HSE statements offshore and onshore vary somewhat in that offshore employees generally have a more positive assessment of the HSE climate than those onshore. But where in the offshore results it is apparent that the assessment has changed for the worse in several areas, among onshore facilities several places have experienced a change for the better. Common to both is that negative changes relate to statements dealing with increased production pressure. These factors may be linked to reorganisation and downsizing in the industry. For example, assessments of statements such as "Deficient maintenance has led to poorer safety" and "Career-wise, it is a drawback to be concerned about HSE" have shown a negative trend since 2013.

In terms of psycho-social working environment, it is having to work at a high pace that is challenging both onshore and offshore. Offshore, there has been a significant negative development here. There is a development offshore towards less control and increased

pressure of work. This tendency is not as evident onshore, but we see there a weakly negative development in social support.

A similar proportion state that they have had a work accident involving personal injury in recent years (between 3 and 4%), but the degree of reporting to their manager differs. While 80% of offshore employees have reported their injuries upwards, onshore this proportion is 89%.

5. Status and trends - DFU12, helicopter incidents

The cooperation with the Civil Aviation Authority and the helicopter operators was continued in 2015. 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, 2016a) contains additional information about the scope, constraints and definitions.

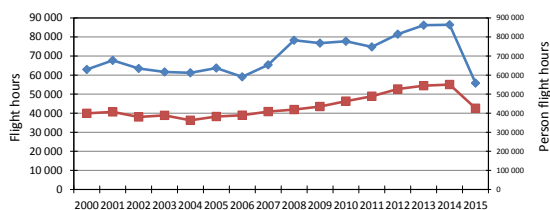
During the period of RNNP data collection, there have been no helicopter accidents involving personal injury or fatality on the NCS. The last fatal helicopter accident on the NCS occurred on a flight to the Norne field in 1997.

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.

5.1 Activity indicators

Figure 3 shows activity indicator 1 (transport service) and activity indicator 2 (shuttle traffic) as the number of flight hours and number of person flight hours per year in the period 2000-2015. For the transport service, the number of person flight hours showed a slightly increasing tendency in the years 2004-2014, while there was a drastic decline from 2014 to 2015 (35.4%).

TRANSPORT SERVICE



SHUTTLE TRAFFIC

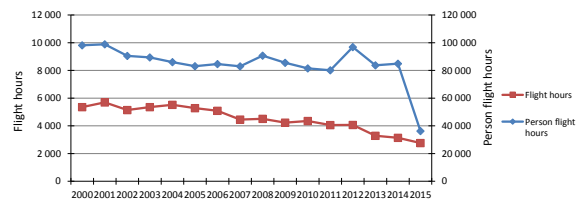


Figure 3 Volume of transport service and shuttle traffic, person flight hours and flight hours, 2000-2015

The annual volume of transport service must be viewed in the context of the activity level on the NCS (see the main report), which shows a relatively stable rise in the number of working hours in the period from 2000 to 2014. Working hours on production facilities fell by nearly 19% from 2014 to 2015. For mobile facilities, the reduction for the same period was around 4%. The decline in both flight hours and person flight hours that we see in the indicator is however greater than the fall in working hours should indicate.

Activity indicator 2 covers the volume of shuttle traffic per year in the period 2000-2015. Shuttle traffic comprises passenger transport in which the helicopter's departure and arrival concern a single facility. Figure 3 shows activity indicator 2, the volume of shuttle traffic, as the number of flight hours and number of person flight hours per year in the period 2000-2015. In general, there has been a reduction in the number of flight hours throughout the whole period. From 2014 to 2015, the decline in flight hours is a full 11.9%. The number of person flight hours was rather more variable in the period with a marked decline in 2015 (57.2%).

5.2 Incident indicators

5.2.1 Incident indicator 1 – serious near-misses

Figure 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 on a finer scale, 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

Incident indicator 1 includes the events with little or medium remaining margin against fatal accidents for passengers, i.e. no or one remaining barrier. In the years 2006 and 2007, there was one incident in each year with no remaining barriers, while there were two such incidents in 2008. There were no incidents without remaining barriers against fatal accident in the years from 2009 to 2013, whereas in 2014 one incident was assessed as being in this category. There were no incidents recorded for this incident indicator in 2015. As previously, incidents during the parked phase onshore are not included.

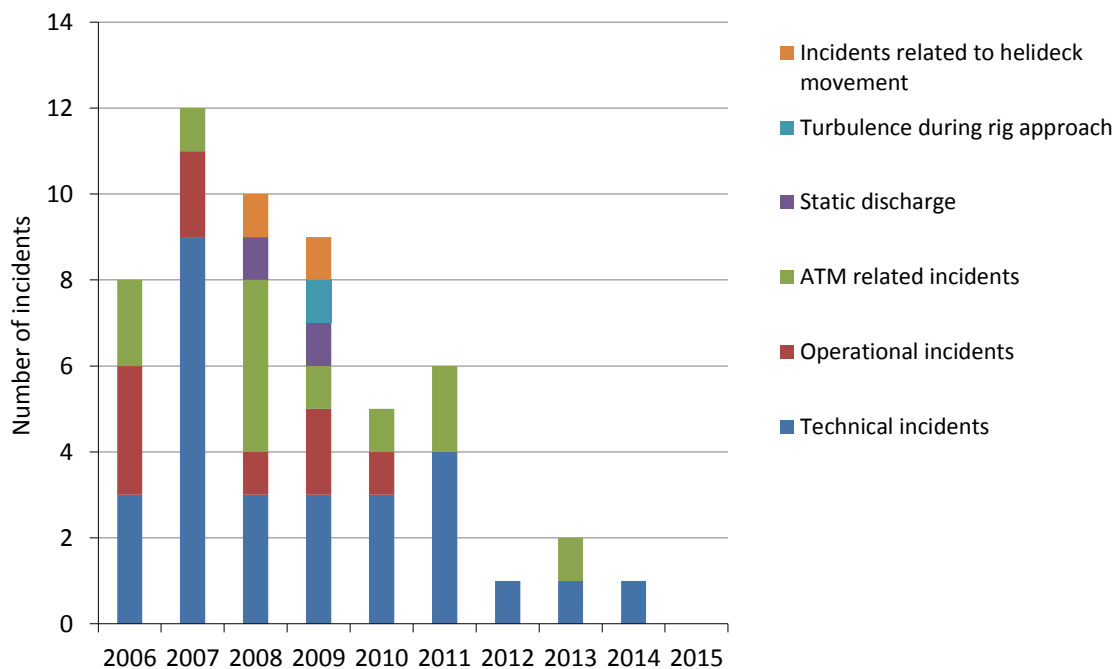


Figure 4 Incident indicator 1, incidents with little or medium remaining safety margin, 2006–2015

5.2.2 Incident indicators linked to causal categories.

As of 2009, incident indicator 3 has been replaced by 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. Data for 2008-2015 are presented in Figure 5–Figure 7. There was a strong reduction for helideck factors in 2010 compared with 2009. In the period 2010 to 2014, there was a significant reduction in the number of incidents relating to helidecks. In 2015 there was a small increase in the number of incidents, as shown in Figure 5. A change in reporting practice may be assumed to have contributed to the increase in 2015.

Figure 6 shows the number of incidents included in incident indicator 4, ATM aspects. The number of incidents included in the indicator in 2015 rose sharply, almost doubling, compared with 2014. 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. In 2014 and 2015, incidents linked to deficient radio communication with air traffic services are almost completely absent. The largest contributor in 2015 relates to near misses (6 out of 29 recorded incidents).

Figure 7 shows the number of incidents included in incident indicator 5, bird strikes. After a low number of recorded incidents with a safety impact relating to bird strikes in the years from 2010 to 2013, there was an increase to 7 incidents in 2014. The number of incidents included in the indicator in 2015 shows a small reduction compared with 2014. In contrast to previous years, in 2015 no incidents without a safety impact relating to bird strikes were recorded.

Helicopters of the latest generation are to be more robust in terms of bird strikes. A decision may therefore be made as to whether this indicator may be dispensed with when the entire helicopter fleet on the NCS consists of latest generation craft. The increase in the number of recorded incidents with a safety impact in 2014 and 2015 may perhaps weigh against this.

In relation to improvement suggestions, no new proposals were identified in this year's report. The proposals from previous years' RNNP are being followed up, including in the year ahead. For information and comments about this follow-up, please refer to the main report (PSA, 2016a).

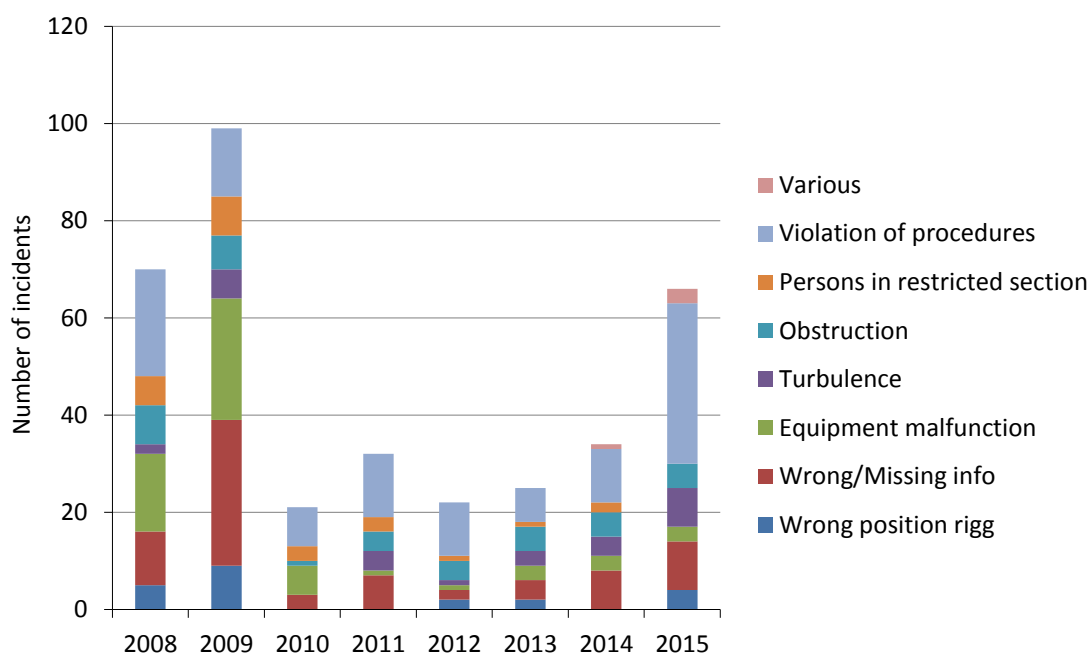


Figure 5 Helideck factors, 2008–2015

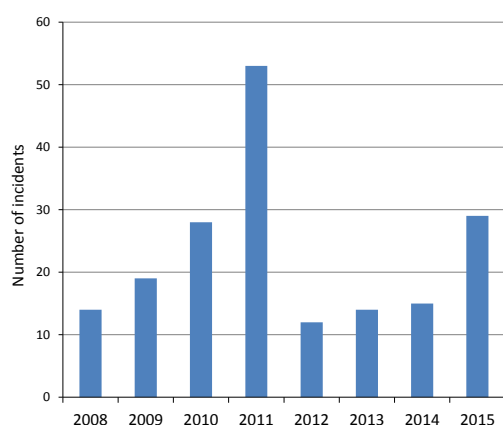


Figure 6 ATM aspects, 2008–2015

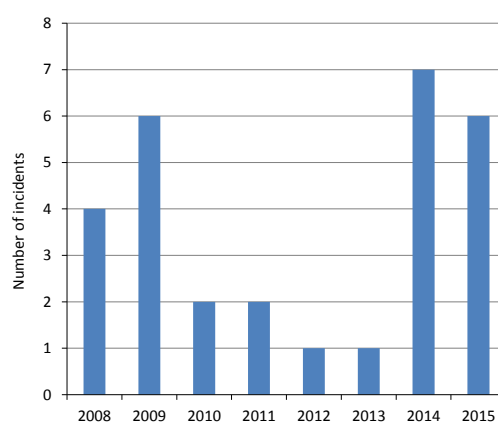


Figure 7 Bird strikes, 2008–2015

6. 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. Indicators for major accident risk involving helicopters are discussed in Chapter 4, and barriers against major accidents in Chapter 7.

There have been no major accidents, per the definition used in the report, on facilities on the NCS since 1990. The serious incident on COSL Innovator where a wave stove in windows in an accommodation section, injuring 4 and killing one person, is categorised as a construction 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; see also page 17 in connection with the helicopter accident outside Brønnøysund in 1997. Neither have there been any ignited hydrocarbon leaks from process systems since 1992, apart from the occasional minor leak which is not considered to have the potential for resulting in major accidents.

The most important individual indicators for production and mobile facilities are discussed in sub-chapter 6.2. The other DFUs are discussed in the main report. The indicator for total risk is discussed in sub-chapter 6.3.

6.1 DFUs associated with major accident risk

Figure 8 shows the trend in the number of reported DFUs in the period 2004-2015. It is important to emphasise that these DFUs contribute very differently to the risk indicator. There was a clearly rising trend during the period 1996-2000, which has been discussed in previous years' reports and is therefore omitted from the figure. After 2002, there was a reduction in the number of incidents up to 2007. After 2007, we observe minor variations around a stable level of some 70 incidents per year. In 2012, there was a marked reduction which continued in 2013 and 2014. In 2015, we see an increase in the number of incidents relative to 2013-2014.

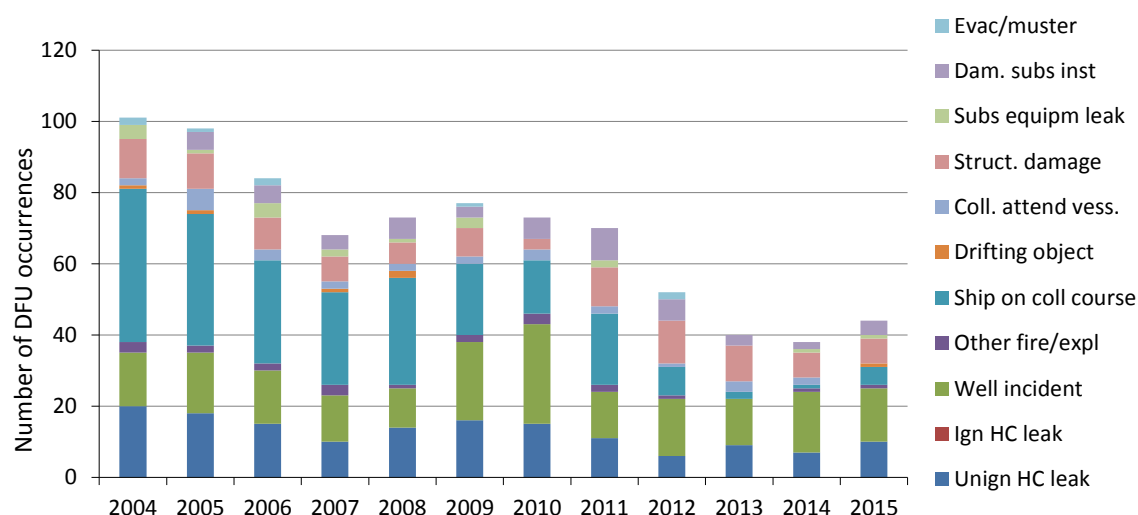


Figure 8 Reported DFUs (1-11) by categories

6.2 Risk indicators for major accidents

6.2.1 Hydrogen leak in the process area

Figure 9 shows the number of hydrocarbon leaks greater than 0.1 kg/s in the period 2000-2015. There was a clear fall in the number of hydrocarbon leaks from 2002 to 2007. The number of leaks above 1 kg/s was fairly stable in the same period. In 2015, no leaks were recorded in the category >10 kg/s, while four leaks were recorded in the category 1-10 kg/s, and six in the category 0.1-1 kg/s.

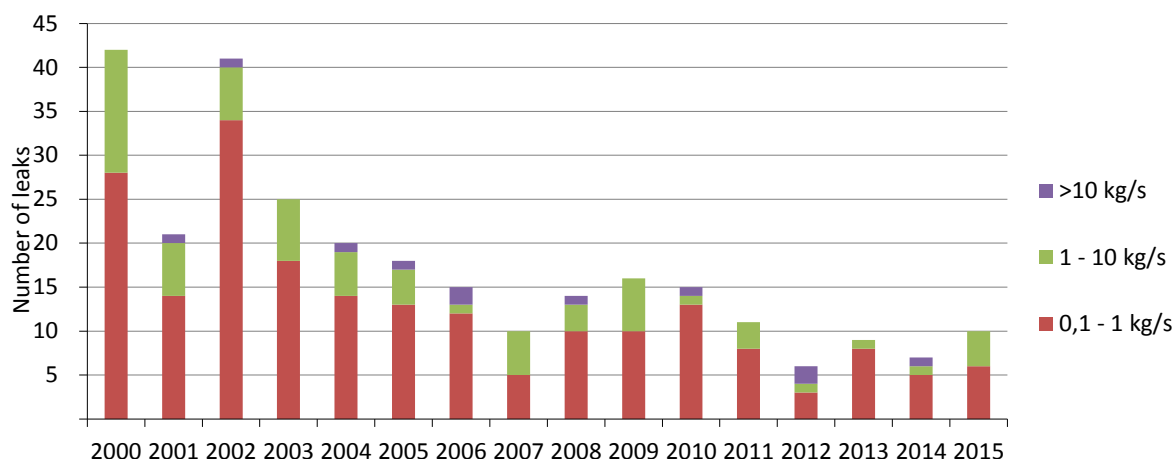


Figure 9 Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2015

Figure 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 contribution derives from two incidents in 2015 of 6.9 kg/s and 8 kg/s, which are in the upper echelon of the 1-10 kg/s category.

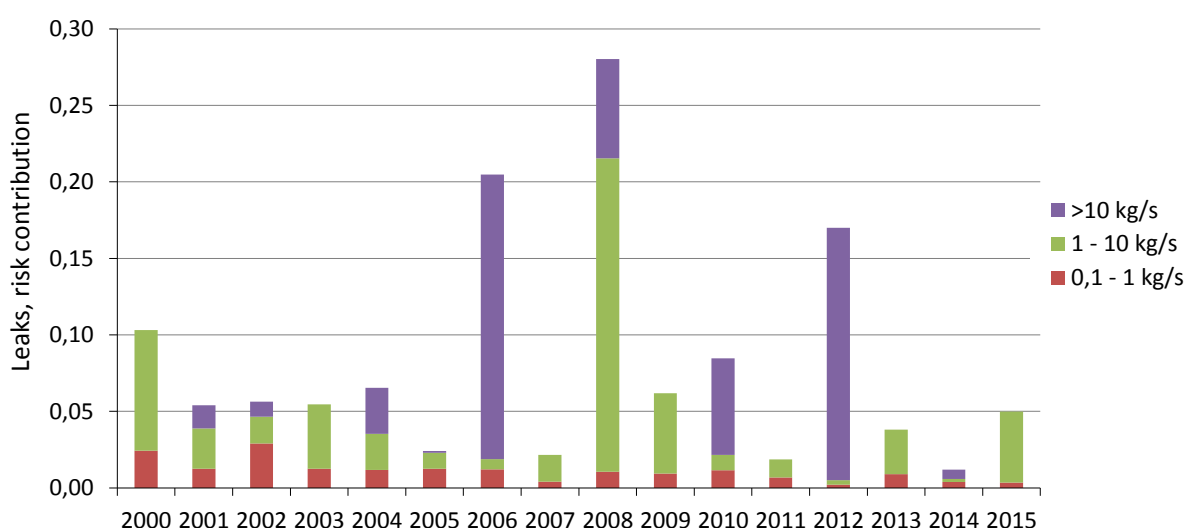


Figure 10 Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-201, weighted according to risk potential

Figure 11 shows the trend in leaks exceeding 0.1 kg/s, normalised against facility years, for all manned production facilities. The figure illustrates the technique used throughout to assess the statistical significance (validity) of trends. Figure 11 shows that, despite the increase in the number of leaks per facility year in 2015, the number is within the prediction interval and is not statistically significant relative to the average for the period 2005-2014. This is indicated by the height of the column for 2015 being within the middle grey-shaded area in the column on the far right of the figure ("Int 05-14", see also the methodology report). The number of leaks has been normalised both against working hours and against the number of facilities in the main report.

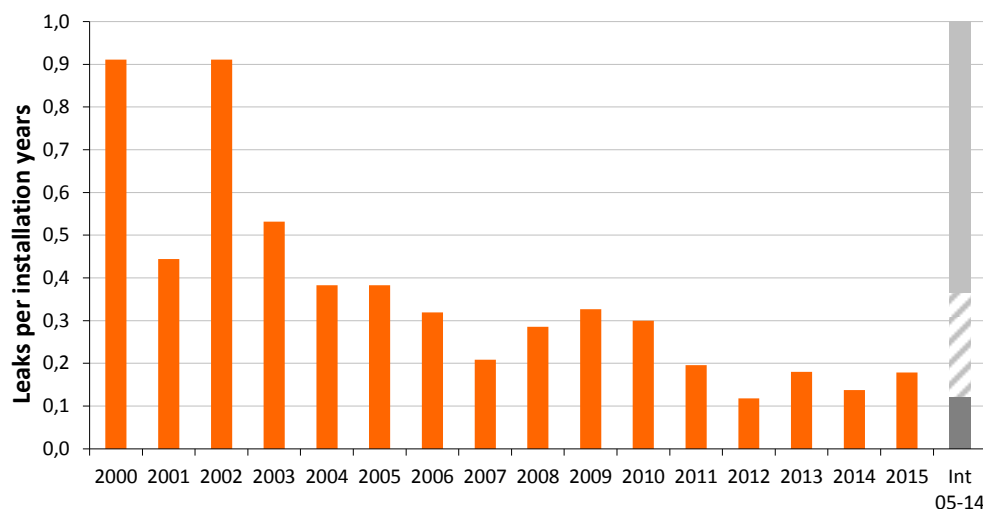


Figure 11 Trend, leaks, normalised against facility years, manned production facilities

There is considerable variation between operators in terms of the frequency of leaks exceeding 0.1 kg/s. These differences have been nearly constant over many years, which shows that there is clearly still a potential for improvement. This is also underscored in Figure 12, which shows the average leak frequency per facility year for the operating companies on the NCS. The figure shows data from the last five years. For operator 16, this is due to the high level of short operating times.

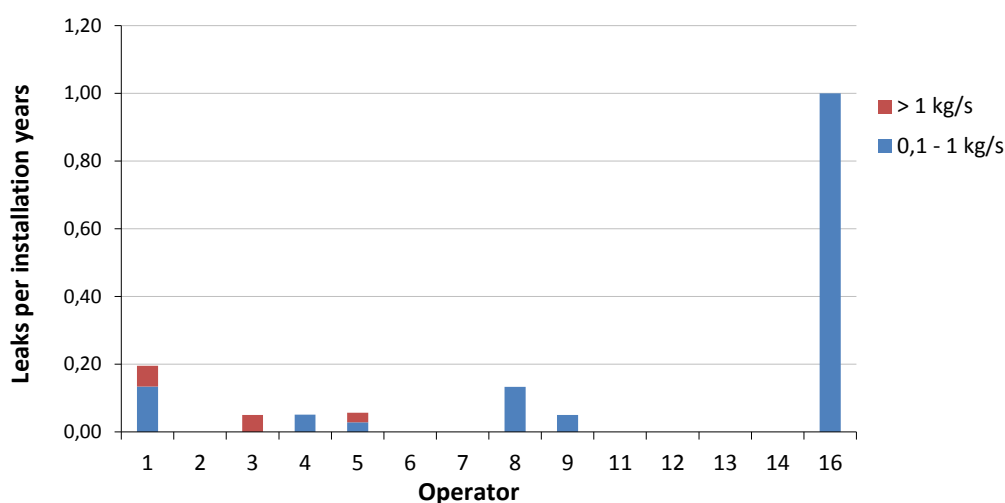


Figure 12 Average leak frequency per facility year, 2011-2015

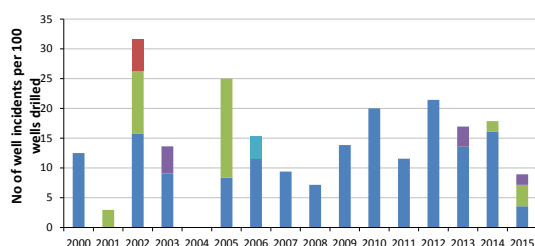
6.2.2 Loss of well control, blowout potential, well integrity

Figure 13 shows the occurrence of well incidents broken down by exploration drilling and production drilling, normalised per 100 drilled wells. Both exploration drilling and production drilling are shown together and on the same scale for comparison.

For exploration drilling, there were major variations throughout the period. There was a considerable reduction during the period 2005-2008 and significant variation during 2009-2015. The level during this period appears to represent a break with the positive trend during 2005-2008. For 2015, there is a marked reduction in the number of incidents for exploration drilling relative to the three preceding years. But, as mentioned, there was considerable variation in the period 2009-2015.

Incidents during production drilling saw a continuously rising trend until 2003, with minor variations. During the period from 2004 to 2008, there was a fall, and then an increase in 2009 and 2010. Since 2010 there was a declining trend for production drilling up to 2013. The level in 2015 rose somewhat relative to the level in 2014, but is not statistically significant compared with the average of the period before. In 2015, all the well control incidents, except three, are in risk category level 3, i.e. incidents with minor potential. The three incidents were in risk category level 2.

EXPLORATION DRILLING



PRODUCTION DRILLING

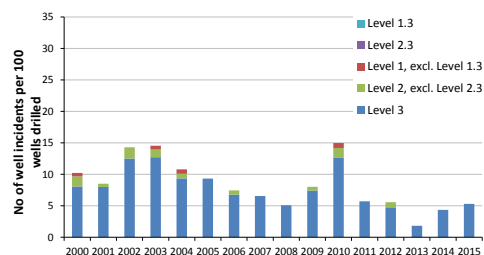


Figure 13 Well incidents by severity per 100 wells drilled, for exploration and production drilling

Figure 14 shows an overview of all well control incidents (for exploration and production wells) in relation to the areas on the NCS where the well control incidents have occurred. The area divisions correspond to the same divisions used on the Norwegian Petroleum Directorate's shelf map.

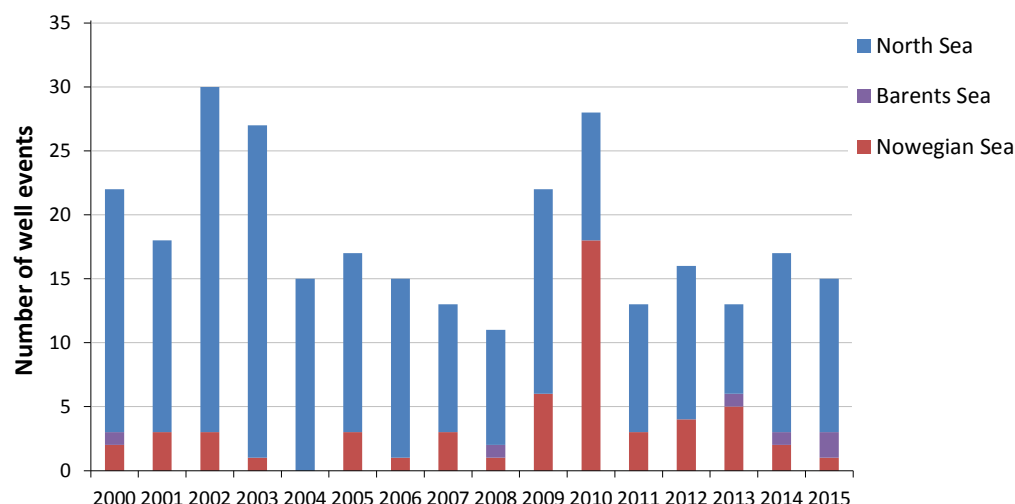


Figure 14 Distribution of well control incidents by areas, 2000-2015

The Well Integrity Forum (WIF) established a pilot project for key performance indicators (KPIs) for well integrity in 2007. A total of 15 operating companies have reviewed all their "active" wells on the NCS, a total of 1911 wells in 2015, with the exception of exploration wells and permanently plugged wells. 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 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.

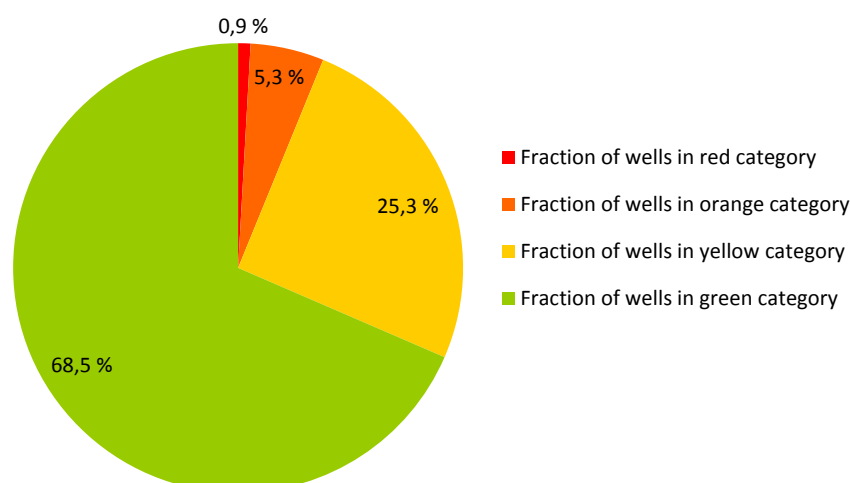


Figure 15 Well categories - red, orange, yellow and green, 2015

The mapping shows an overview of well categories distributed according to the percentage of the total sample of 1911 wells.

The results show that 6.2 % of the wells have reduced quality compared with the requirement for two barriers (red + orange category). 25.3 % of the wells are in the yellow category. This includes wells with reduced quality compared with the requirement for two barriers, but the companies have compensated for this through various measures such that they are deemed to comply with the requirement for two barriers. The rest of the wells, i.e. 68.5 %, are in the green category. These are deemed to be in full compliance with the requirement for two barriers.

There was an increase in the percentage of wells in the top three categories from 24% to 31% from 2009-2015. The development in the different categories is shown in Figure 16.

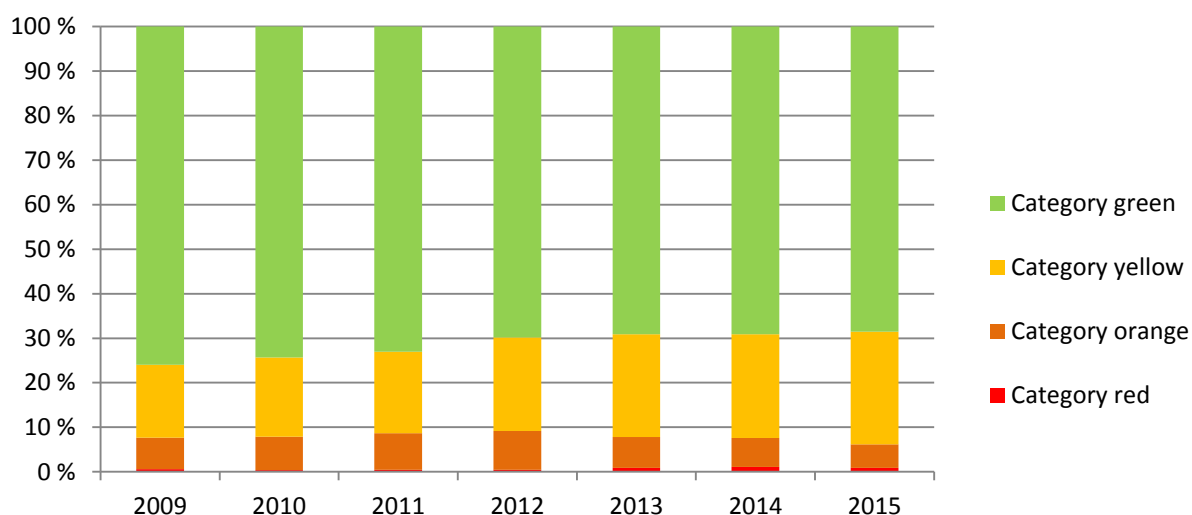


Figure 16 Development in well categories, 2009-2015

6.2.3 Leak/damage to risers, pipelines and subsea facilities

One leaks from a riser to a production facility was reported in 2015. This was a 12" steel production riser for oil/gas. The leak was caused by corrosion damage. The leak rate was very low, 0.12 kg/s, with 96% water cut in the riser, and the incident was therefore assigned a relatively low weighting. No leaks from pipelines were reported in 2015.

In 2015, four incidents of serious damage to risers and pipelines within the safety zone were reported.

Serious damage to risers and pipelines is also included in the calculation of the total indicator, but with a lower weighting than for leaks. Figure 17 shows an overview of the most serious incidents of damage within the safety zone during the period 2000-2015.

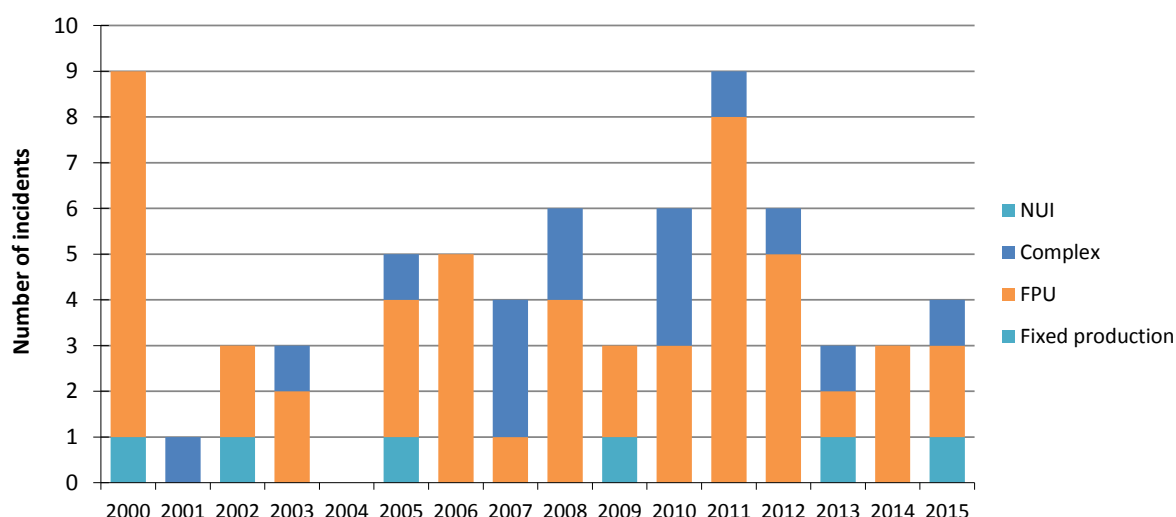


Figure 17 Number of incidents involving serious damage to risers & pipelines within the safety zone, 2000-2015

6.2.4 Ships on collision courses, 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.

For 12 years, there has been an indicator for DFU5, where the number of ships reported on a potential collision course 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 recorded instances of ships on a collision course has declined substantially in recent years.

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. In 2015, a total of five ships on collision courses were recorded.

There was one collision incident in 2015; a minor collision occurred when Esvagt Dee came to pick up containers on Petrojarl Varg (FPSO). This resulted in paintwork scratches to both vessels of the order of 10x20 cm, but no structural weaknesses.

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, selected 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 flotel 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 serious consequences.

Structural damage and incidents that have been included in RNNP are primarily classified as fatigue damage, but 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 2000-2014 is shown in Figure 18.

In 2015, a total of seven structural incidents were recorded, one relating to anchor lines, one DP incident and five fracture incidents. None of the incidents in 2014 is categorised as especially serious. The high number of incidents in the period 2011-2012 appears to constitute a break in the positive trend observed for the period 2004-2010.

- A serious incident on COSL Innovator with waves in the deck box, which stove in windows in an accommodation section. Four persons were injured and one died.

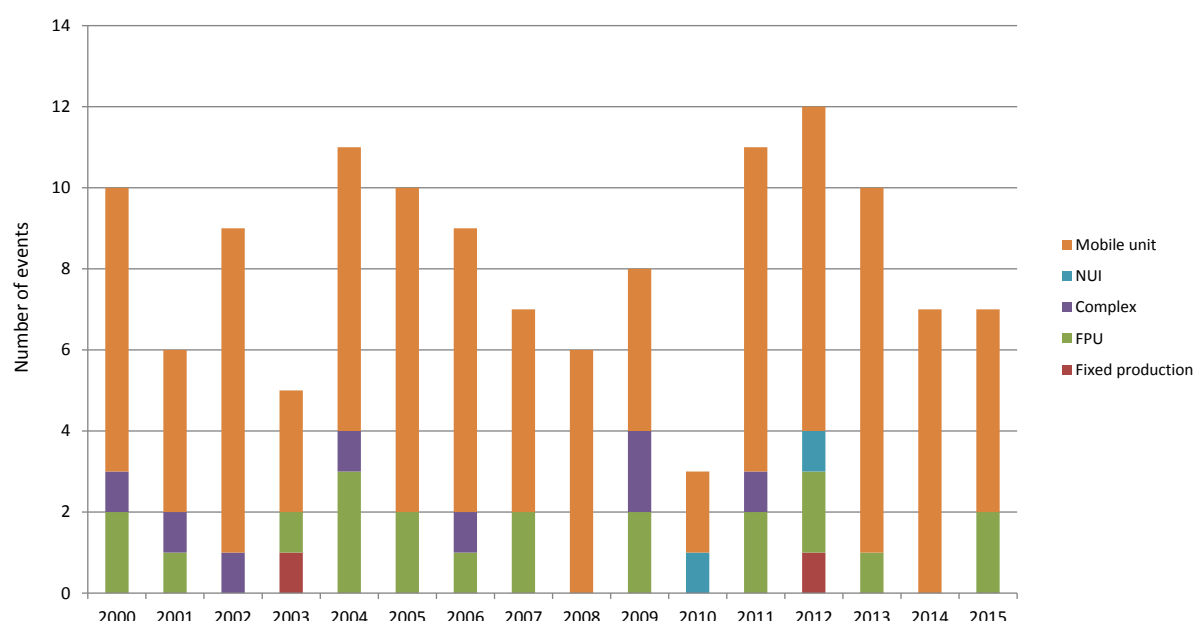


Figure 18 Number of serious incidents and incidents involving damage to structures and maritime systems which conform to the criteria for DFU8

6.3 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 risk 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 observations of the individual DFUs. Figure 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 long-term trend. Working hours have been used as a common parameter for normalisation against the 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.

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.

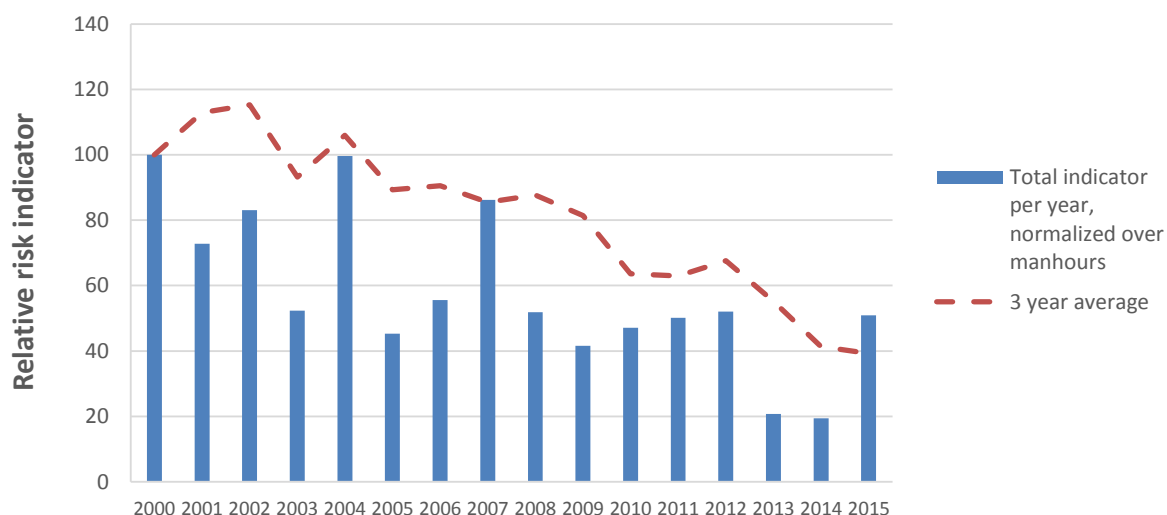


Figure 19 Total indicator, production facilities, normalised against working hours, annual values and three-year rolling average

Figure 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 structure-related incidents. Following higher values in 2012, the value for the rolling average in 2015 is significantly below the level from 2005-2014, despite there being a clear increase in the risk indicator from 2014 to 2015. The value for 2015 is somewhat lower than in 2012. The contribution from structural damage and incidents involving maritime systems has been high on mobile facilities for many years.

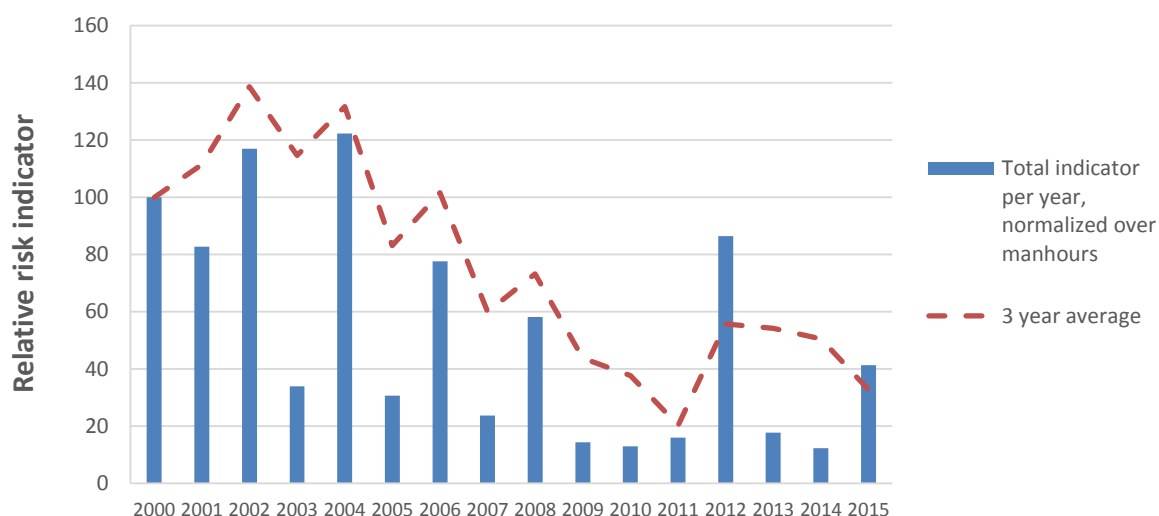


Figure 20 Total indicator, mobile facilities, normalised against working hours, annual values and three-year rolling average

7. 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.

7.1 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 implemented.

Figure 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.

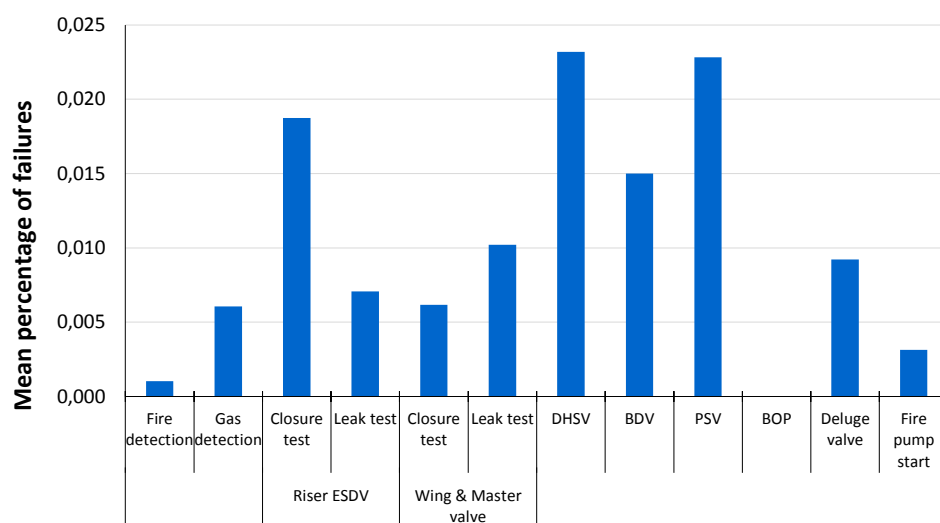


Figure 21 Mean percentage of failures for selected barrier elements, 2015

The main report shows the difference between the mean percentage of failures (Figure 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. Figure 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 2015, the average percentage of failures during the period 2007-2015, as well as the total number of tests carried out in

2015 (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 ESDV closure test in 2015.

The industry standard for the ESDV closure test is 0.01, and the figure above shows that eight facilities exceed the industry standard for the percentage of failures in 2015 and 19 facilities for the average value.

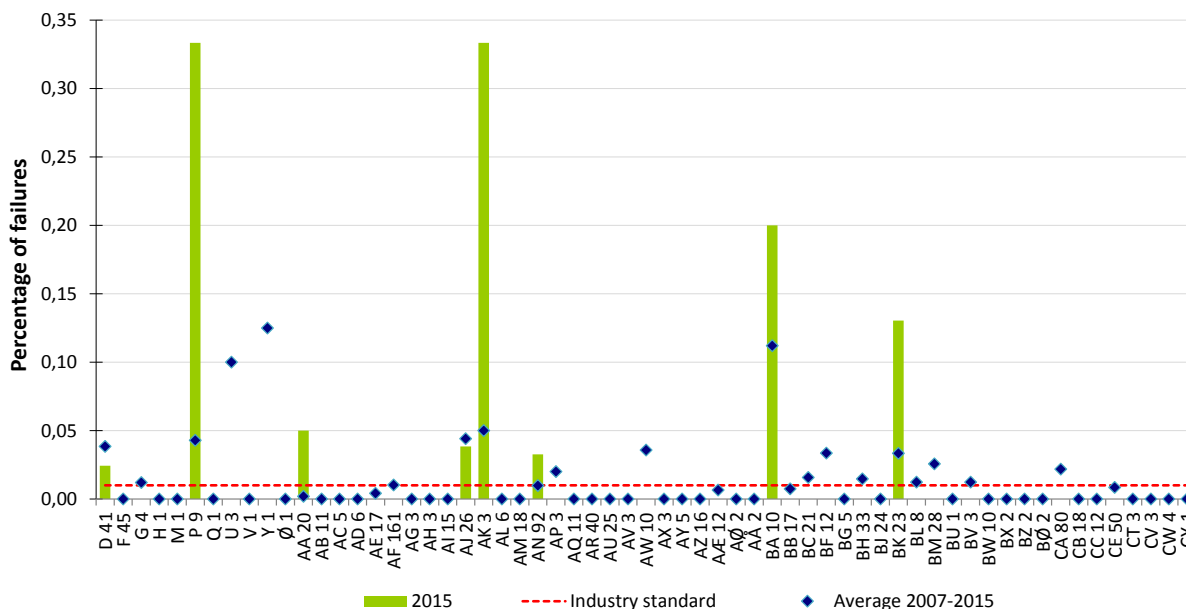


Figure 22 Percentage of failures for riser ESD valves (closure test)

As regards production facilities, barrier data has now been collected for 12 years for most barriers. Overall, many facilities performed below or far below the industry standard for several of the barrier elements, both in 2015 and on average for the entire period. Taking into account the industry's recent focus on major accident prevention, one would expect it to be possible to achieve greater improvements in this area than are shown by data from recent years.

Table 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 2015 and for the period 2002-2015. 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 2015 and the mean percentage of failures for 2002-2015 for riser ESDVs and blowdown valves (BDVs) are above the industry standard. The same applies to the mean percentage of failures for 2002-2015 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 2015	Average, number of tests, for facilities where tests were performed in 2015	Number of facilities with a percentage of failures in 2015 (and avg 2002-2015)* ¹ higher than industry standard	Mean percentage failures in 2015	Mean percentage failures 2002-2015	Industry standard for availability (Statoil)
Fire detection	73	692	1 (5)	0.001	0.004	0.01
Gas detection	73	340	15 (15)	0.006	0.008	0.01
Shutdown:						
· Riser ESDV	62	25	10 (28)	0.013	0.019	0.01
Closure test	61	16	8 (19)	0.019	0.019	0.01
Leak test	59	9	4 (18)	0.007	0.016	0.01
· Wing and master (Christmas tree)	72	243	9 (6)	0.009	0.010	0.02
Closure test	71	122	8 (3)	0.006	0.007	0.02
Leak test	72	122	12 (8)	0.010	0.011	0.02
· DHSV	72	103	23 (29)	0.023	0.020	0.02
Blowdown valve (BDV)	61	56	15 (45)	0.015	0.022	0.005
Pressure safety valve (PSV)	71	171	16 (13)	0.023	0.025	0.04
Isolation using BOP	29	108		0.00	0.017	* ²
Active fire safety:						
· Deluge valve	71	30	10 (23)	0.009	0.012	0.01
· Start test	63	120	11 (12)	0.003	0.003	0.005

7.2 Barriers associated with maritime systems

In 2015, 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.
- CM 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

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.

year. Approx. 10,000 tests of watertight doors and approx. 600,000 tests of ballast valves on mobile facilities were carried out in 2015.

The failure frequencies for these systems in 2015 were 0.005 for tests on watertight doors and 0.001 for tests on ballast valves. The failure frequency for testing of watertight doors is higher than for production facilities, that had zero reported faults in 2015. The failure frequency for testing of valves in the ballast system is also higher for mobile facilities compared with this failure rate for production facilities.

7.3 Indicators for 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. Maintenance is a key aspect of barrier management. It is a necessary prerequisite for maintaining the performance of a barrier and for being able to improve its condition/performance over time.

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.

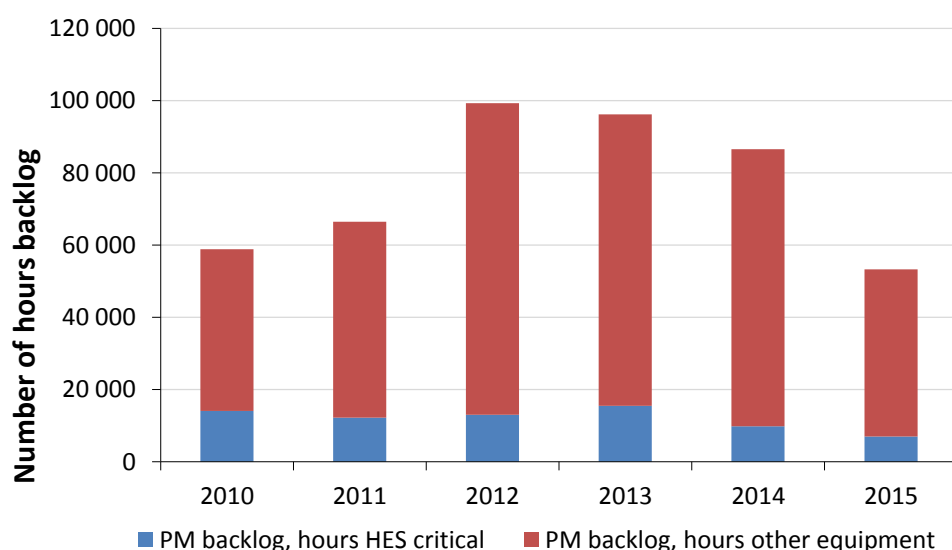


Figure 23 Total backlog in PM per year in the period 2010-2015 for the production facilities on the NCS

Figure 23 shows a clear reduction in 2015 in the total backlog of preventive maintenance, both for HSE-critical equipment and equipment in general. The figures for 2015 are the lowest since reporting began in 2010. Backlogs in the HSE-critical preventive maintenance may contribute to increased uncertainty with regard to technical condition, and hence the risk level.

Figure 25 Total outstanding HSE-critical PM per year in the period 2010-2015 for the production facilities on the NCS

Figure 25 shows a clear fall in the total of outstanding HSE-critical corrective maintenance for 2015 compared with previous years.

Figure 26 shows the number of hours of *performed maintenance, modifications and planned shutdowns* for all facilities for the period 2010-2015.

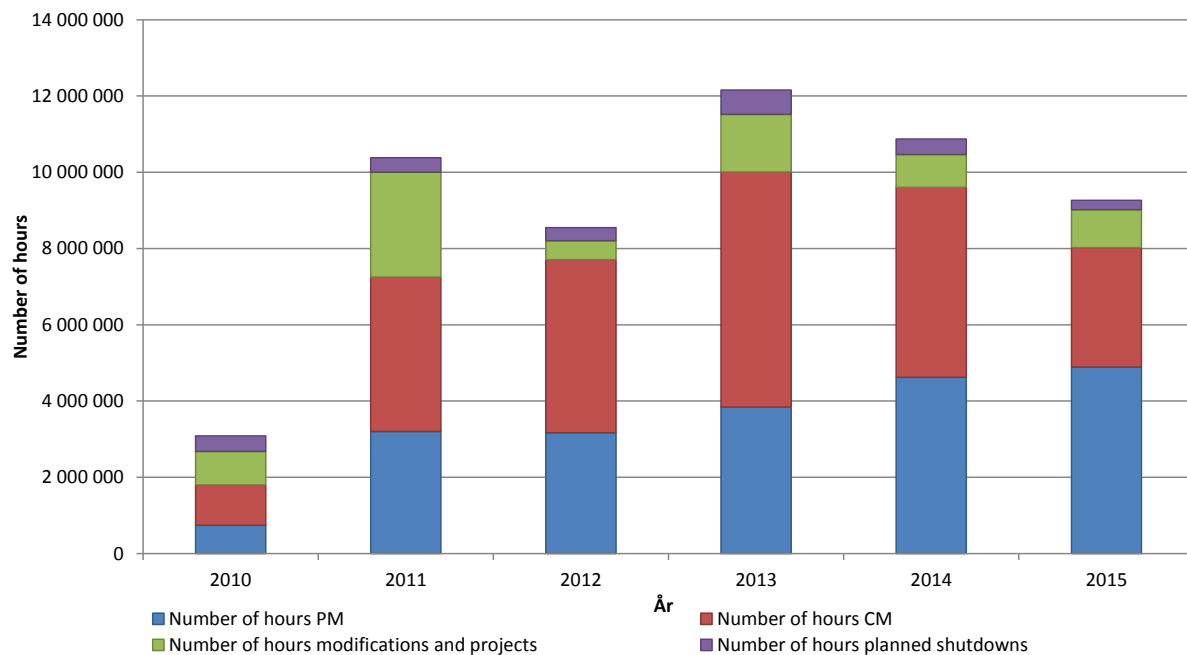


Figure 26 Hours worked in the period 2010-2015. Not all the participants reported figures for 2010

Figure 26 is especially intended to show the distribution of the maintenance activities. We see that hours of corrective maintenance performed were lower in 2015 than in the years 2011-2014. At the same time, we see that hours of preventive maintenance performed increased in the period 2011-2015.

We note that:

- there is a clear reduction in 2015 in the total backlog of preventive maintenance, both for HSE-critical equipment and equipment in general
- a few facilities have a high total number of hours of corrective maintenance not performed as at 31.12.2015

These observations must be seen in the context that:

- backlogs in the HSE-critical preventive maintenance *may* contribute to increased uncertainty with regard to technical condition, and hence the risk level.
- the significance of unperformed corrective maintenance *must* be assessed both individually and in combination. The assessment is crucial for determining the extent to which unperformed maintenance entails increased risk.

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

For 2015, the PSA registered 252 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 2014, 329 personal injuries were reported. There was one fatal accident within the PSA's area of authority on the NCS in 2015. This occurred on 30.12.2015 on COSL Innovator during a storm. A large wave hit the facility and caused considerable damage to the accommodation module. One person died and four were injured.

In addition, 35 injuries classified as off-work injuries and 30 first aid injuries were reported in 2015. For comparison, in 2014 there were 50 off-work injuries and 38 first aid injuries. First aid injuries and off-work injuries are not included in figures or tables.

In recent years, we have seen a clear reduction in the number of injuries reported on NAV (Norwegian Labour and Welfare Administration) forms, and this trend continued in 2015. In 2015, as many as 40% of the injuries were not reported to the PSA on 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.

From 2005 to 2008, the overall injury rate for production facilities was roughly unchanged at around 11 injuries per million working hours. In 2009, there was a significant fall from 11 to 8.6 injuries per million working hours. This positive trend also continued in the next three years and in this period, the total injury rate was under 8 per million working hours. In 2013, we had a further fall to 7.3 injuries per million working hours and the injury rate remained at the same level in 2014 as well. In 2015, we again see a small positive development in that the injury rate was reduced to 7.1 injuries per million working hours.

As on production facilities, mobile facilities have also seen a positive long-term trend, and the rate is just under one third relative to the 2005 level. The injury rate fell from 11.7 in 2005 to 4.1 in 2015. From 2011 to 2013, the overall injury rate was essentially unchanged at around 7 injuries per million working hours. In 2015, the overall injury rate fell by 1.4 personal injuries per million working hours relative to the preceding year. The rate went from 5.5 in 2014 to 4.1 injuries per million working hours in 2015. This is the lowest recorded rate for the entire period. The activity level on mobile facilities fell by 0.6 million hours from 2014 to 2015.

8.1 Serious personal injuries, production facilities

Figure 27 shows the frequency of serious personal injuries on production facilities per million working hours. Over the long term, there has been a positive trend in the frequency of serious personal injuries on production facilities. Since 2009, there has been a regular downward trend right up to 2013 when we see the lowest injury rate on production facilities for the entire reporting period (0.36). From 2013 to 2015 there was however a small upturn when the injury rate rose from 0.36 in 2013 to 0.46 in 2014 and 0.60 in 2015. The 2015 level is within the prediction interval based on the preceding decade.

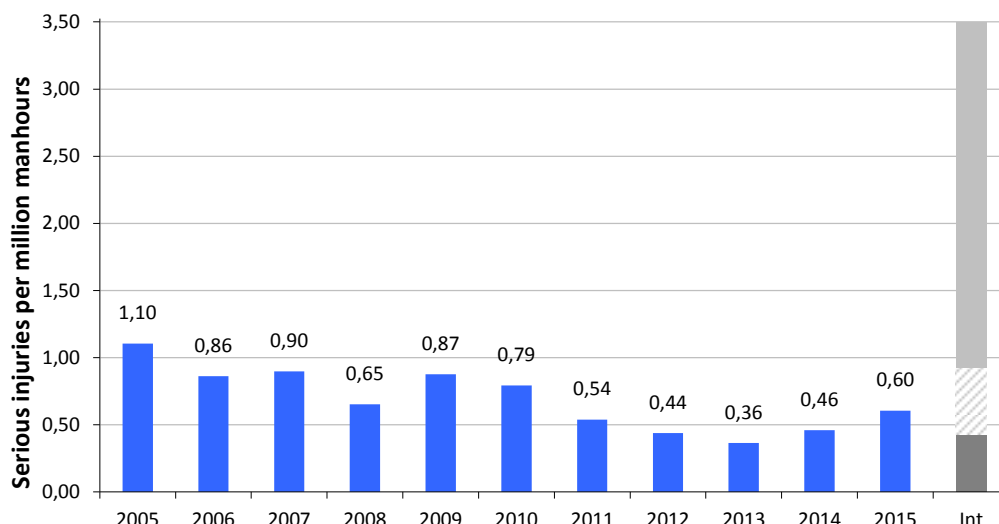


Figure 27 Serious personal injuries on production facilities relative to working hours

8.2 Serious personal injuries, mobile facilities

Figure 28 shows the frequency of serious personal injuries per million working hours on mobile facilities. We can see a marked decline from the first half of the decade to the second half. In 2010, the rate was at its lowest ever, but in the following year we see a marked increase. From 2012 to 2015, there has been a steady rise in the frequency. In 2015, we have an increase in the serious personal injury rate of 0.10 injuries per million working hours from 0.82 in 2014 to 0.92 in 2015. The injury rate is within the expected values based on the preceding 10 years.

The number of hours reported for mobile facilities in 2015 fell by around 0.6 million, from 15.9 to 15.3 million.

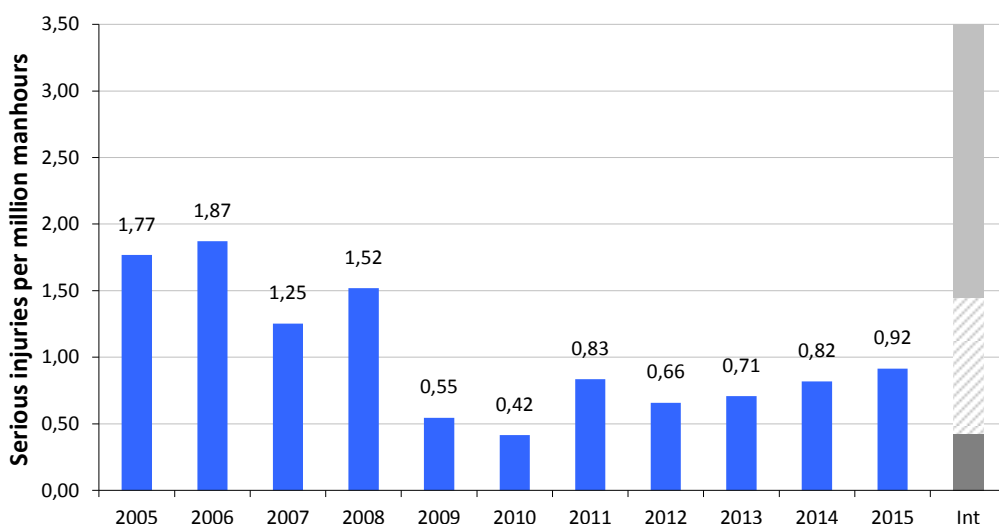


Figure 28 Serious personal injuries per million working hours, mobile facilities

8.3 Comparison of accident statistics between the UK and Norwegian shelves

Every six months, the PSA and the Health and Safety Executive (HSE) produce a joint report comparing offshore personal injury statistics. Classification is performed somewhat differently between the HSE and the PSA. In order to improve the basis for comparison, the PSA, in dialogue with the UK authorities, has classified serious injuries according to joint criteria and such that they include equivalent areas of activity.

A calculation of the average injury rate for fatalities and serious personal injuries for the period from 2009 up to the 2nd half of 2014 shows that there have been 0.6 injuries per million working hours on the Norwegian Continental Shelf and 0.8 on the UK Continental Shelf.

The average frequency for fatalities on the UK Continental Shelf is 1.4 per 100 million working hours, compared with 0.4 on the Norwegian Continental Shelf. This difference is not significant. On the UK Continental Shelf, there were four fatalities during the period in question, compared with one on the Norwegian Continental Shelf.

9. Risk indicators – noise, chemical working environment and ergonomics

Emphasis is given to ensuring that the indicators express risk factors as early as possible in the causal chain that leads to an occupational injury or illness, and furthermore that they are attractive for use in the companies' improvement work.

For noise and chemical working environment, with a few exceptions, data have been registered from all offshore and onshore facilities. The data set for noise is characterised by a shared understanding of the reporting criteria and the indicator appears to provide a realistic and consistent picture of the actual conditions. It also appears to have satisfactory sensitivity to changes in noise levels. For the chemical working environment, changes and adaptations have been made to the indicators introduced in 2004, so that they reflect to best possible effect the actual risk factors. In the last five years, the indicator has been unchanged.

For ergonomics, data were recorded from all onshore facilities and most offshore facilities. Indicators for ergonomic factors have been reported annually in the period 2009-2015. Changes made over time to the data collection form, concerning both questions and more appropriate use of software, mean that consolidated data are most accurately comparable in the period 2012-2015. In 2013, the form was designed in Excel, which entailed both simplification of the actual reporting, and also a more reliable statistical basis.

The indicators are based on a standardised data set and will only capture parts of a complex risk profile. The indicators can therefore not replace the companies' duty to carry out exposure and risk assessments as a basis for implementing risk-reducing measures.

9.1 Noise exposure harmful to hearing

For 2015, data have been reported from 83 facilities, 45 production facilities and 38 mobile facilities. Among the production facilities, 20 facilities are "new" and 25 are "older". By new facilities is meant those with an approved Plan for Development and Operation (PDO) dated since 1 August 1995. At this time, more stringent and detailed noise requirements were introduced (the SAM Regulations). No data were reported from flotels in 2015.

The noise exposure indicator covers 11 predefined position categories. In all, data have been reported for 2,608 individuals, representing approx. 7,800 employees offshore. This is a fall relative to 2014 and 2013.

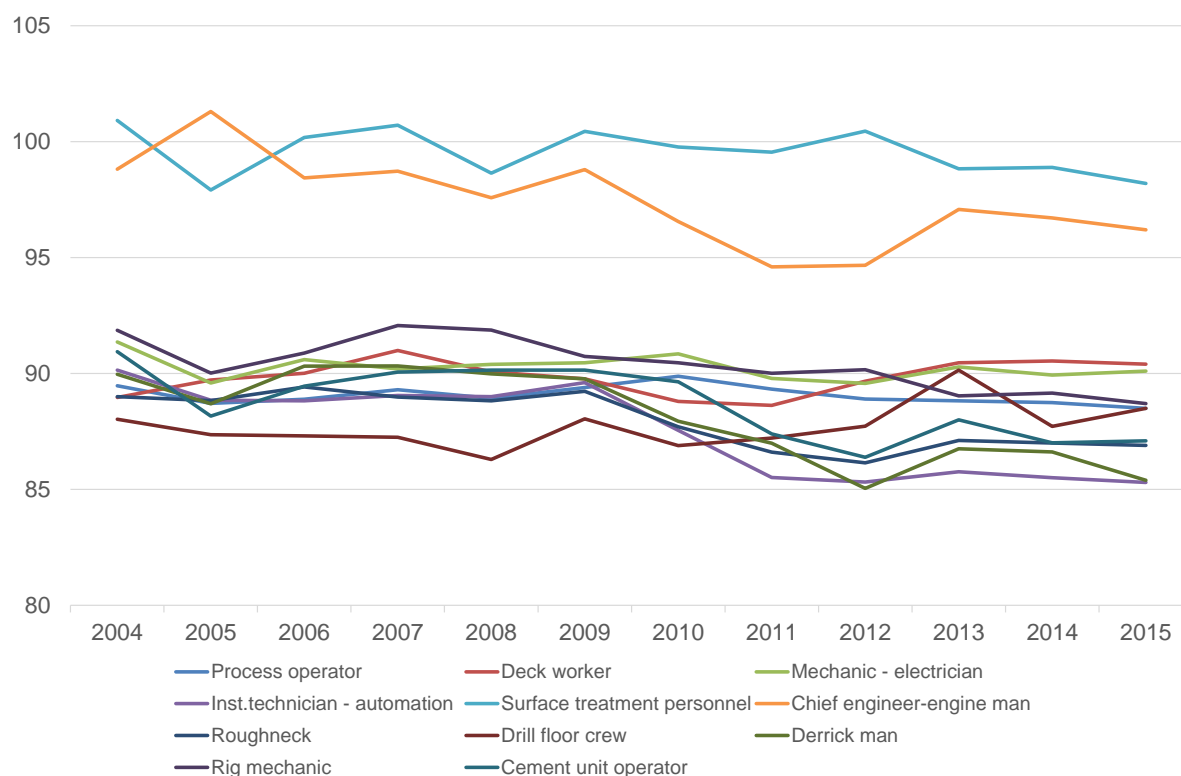


Figure 29 Noise exposure for position categories 2004-2015

The reported noise data for 2015 show an improvement for eight out of 11 position categories. The position categories of mechanics, assistants and cementers show a slight worsening. The average noise indicator value for all NCS activities has been relatively stable in recent years. In 2015, the indicator is 89.1. Most groups show a weak, but relatively even, improvement over the decade. Assuming the noise indicator reflects actual noise exposure, most of the position categories covered by this survey are subject to noise exposure above the threshold value of 83 dBA. If one takes account of the estimated effect of hearing protection as reported by the companies, it appears that the vast majority of position categories are subject to noise exposure within the requirements.

Reporting confirms that several companies have formalised and implemented schemes for working hours restrictions. Of 83 facilities, seven have not introduced such schemes for any position categories. Even though it may be difficult to verify that this type of measure is effective, there are examples to indicate that they do work. Such schemes may have operational disadvantages and may inherently be a driver for more robust technical measures.

In spite of the indicator pointing in the direction of high exposure, several of the facilities still do not have action plans for risk reduction, see Figure 30.

The picture has developed positively for "new" production facilities compared with 2014. For mobile facilities, 76% have established actions plans for risk reduction.

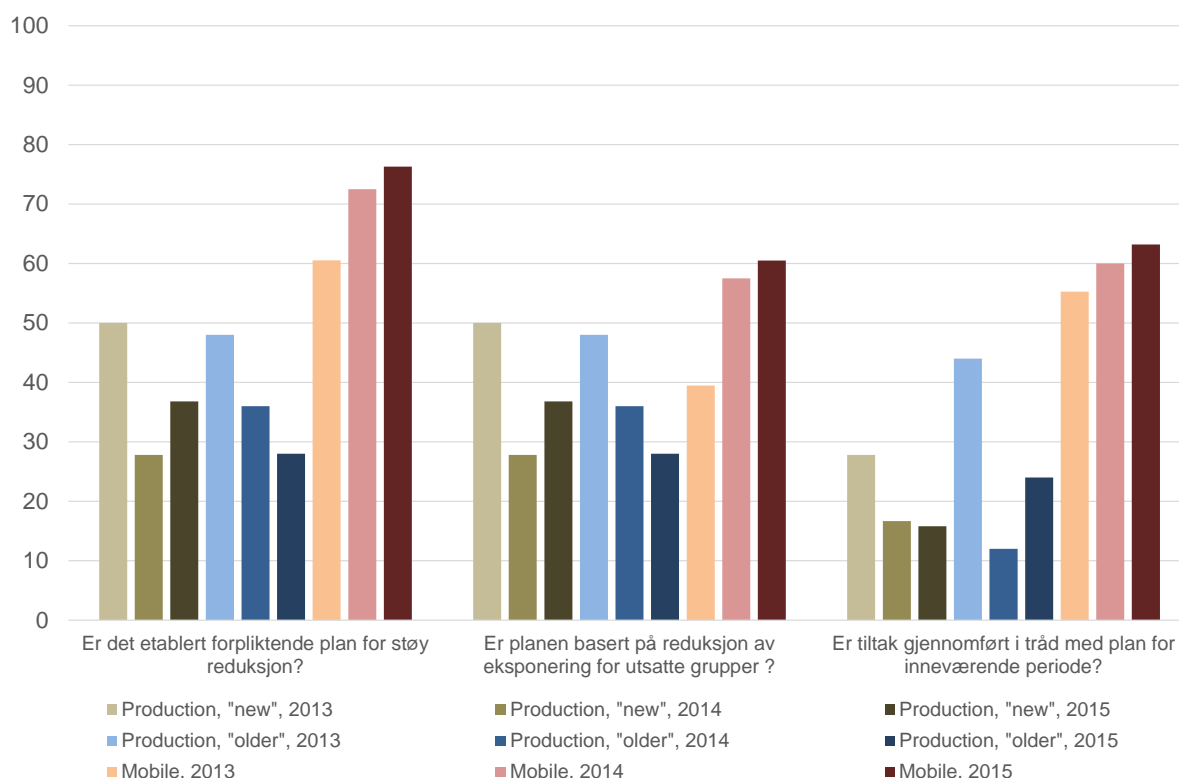


Figure 30 Plans for risk-reducing measures

For 2015, 269 (239 in 2014) new or worsened instances of reduced hearing and 98 (67 in 2014) instances of tinnitus were reported to the Petroleum Safety Authority Norway. There have been relatively large differences in reported harm from year to year. One reason for this is the companies' reporting routines. For 2015, the figures show an increase in the number of new and worsened instances of reduced hearing. The same applies to the number of instances of tinnitus.

9.2 Chemical working environment

The indicator for the chemical working environment consists of two elements. One is the number of chemicals in use, broken down into health hazard categories (the chemical spectrum's risk profile), along with data on substitutions. The other relates to actual exposure for defined position categories, where we attempt to capture exposures with the highest risk.

The indicator for the chemical spectrum's risk profile provides a picture of the number of chemicals in use per facility and how many of these have a high and defined risk potential. The indicator has limitations in that it does not take account of how the chemicals are actually used and the risk this represents. It does, however, say something about the companies' ability to limit the presence and use of potentially hazardous chemicals. It is a professionally recognised argument that the probability of exposure harmful to health increases with the number of hazardous chemicals in use.

For 2015, data have been reported for a total of 82 facilities, 44 production facilities and 38 mobile facilities. No flotel reported data.

The trend data for the chemical spectrum's risk profile for production facilities (Figure 31) and mobile facilities (Figure 32) show a negative trend in the number of chemicals in use on the facilities. For production facilities, there is a marked increase in the number of chemicals with health hazard classification and chemicals with high risk potential from 2014 to 2015.

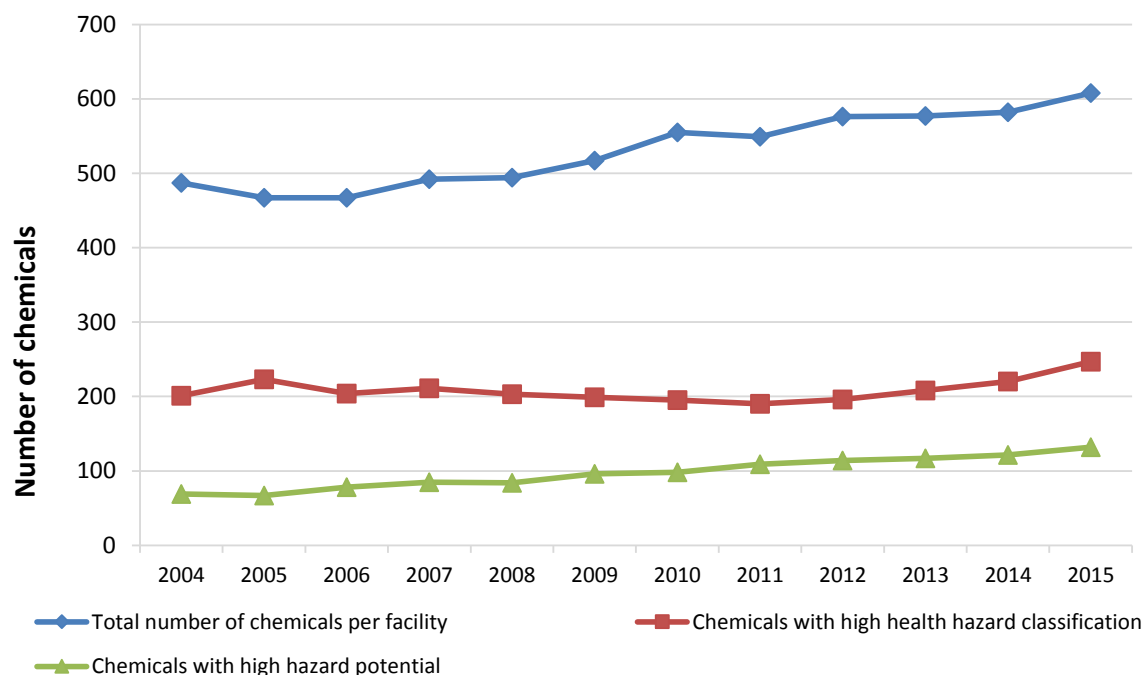


Figure 31 Chemicals per production facility (average) - 2004 to 2015

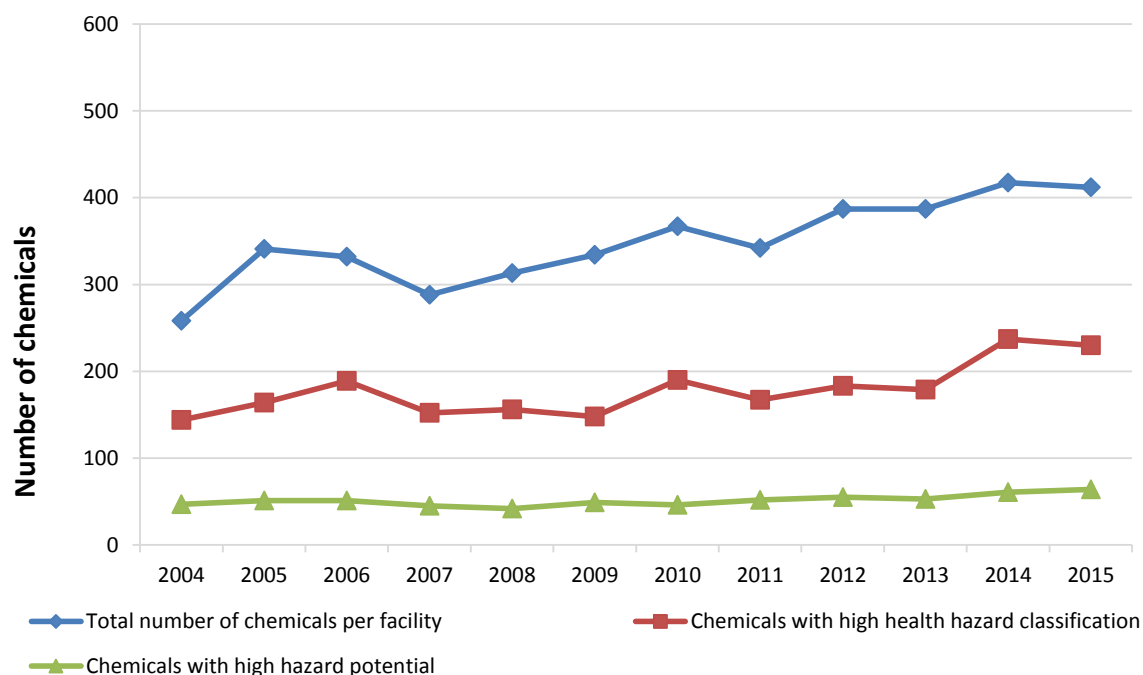


Figure 32 Chemicals per mobile facility (average) - 2004 to 2015

Figure 33 gives a picture of the companies' management of chemical exposure risk. For production facilities, 36% report having established a binding plan for the reduction of chemical exposure on the facility. This is a slight increase relative to 2014. 34 % report having a plan based on the reduction of exposure for vulnerable groups, and 34 % report having implemented measures in line with plans for the reporting period.

For mobile facilities, 97% state having established a binding plan for the reduction of chemical exposure. This is an improvement on the preceding year. Around 80 % report

having a plan based on the reduction of exposure for vulnerable groups, and 92 % report having implemented measures in line with plans for the reporting period.

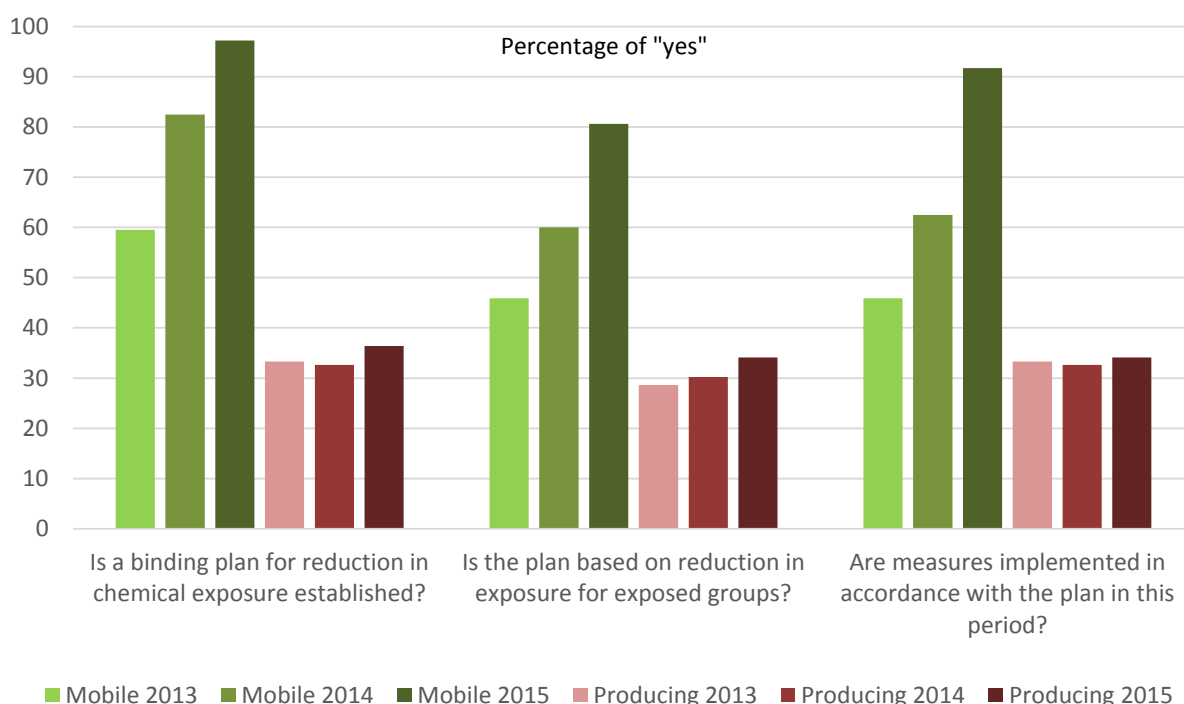


Figure 33 Management of risk of chemical exposure for mobile facilities and production facilities

In 2015, 49 new cases of occupational skin complaints mainly caused by chemical exposure were reported, compared with 50 cases in 2014.

9.3 Ergonomics

Indicators for ergonomic factors have been reported annually in the period 2009-2015. The reporting in 2009 was a pilot scheme, and is not comparable with later years. The questions about risk management were changed in 2012, and, in addition, up to 2012 the reporting was largely deficient in terms of completion of "overall assessment" and was therefore qualitatively inadequate. Trends from before 2012 can therefore not be displayed. However, all results in the period 2012-2015 are comparable. Improvements were made in the design of the form in 2013 and 2014, in order to simplify and improve submissions and achieve more unified reporting.

The indicator has been developed in cooperation with specialist groups in the companies and STAMI. The status overview "Work as a cause of musculoskeletal disorders" was prepared by STAMI in 2008 on assignment from the Norwegian Labour Inspection Authority and the Petroleum Safety Authority Norway, and has been used as a basis in developing the indicator. The Regulations concerning organisation, management and participation and the Regulations concerning the performance of work, use of IT equipment and associated technical requirements specify, in Chapter 23, the assessment criteria on which reporting must be based. The use of ergonomic specialist personnel has been emphasised by the Petroleum Safety Authority Norway.

Data have been reported from 53 production facilities and 36 mobile facilities. 1,509 work tasks were reported by the production facilities and 855 by the mobile facilities.

In the reporting form, working position, repetition, lifting/carrying and hand-held tools were classified as working environment factors. These factors were evaluated as red, yellow or green. In the *red* area, the probability of sustaining repetitive strain injuries is very high. A change in the working conditions from red to green will be necessary. In the *yellow* area, there is a certain risk of developing repetitive strain injuries over the short or

long term, and the strains must be assessed more closely. Aspects such as the duration, tempo and frequency of the strain are particularly important. The combination of the strains may have an amplified impact. In the *green* area, there is a minor risk of repetitive strain injuries for most employees.

Reporting in recent years has become qualitatively better than previously. This is due to the new template for reporting implemented in 2013, which produces more consistent reporting. However, in 2015 too, there were individual cases of the old form being used and of changes made to predefined work tasks.

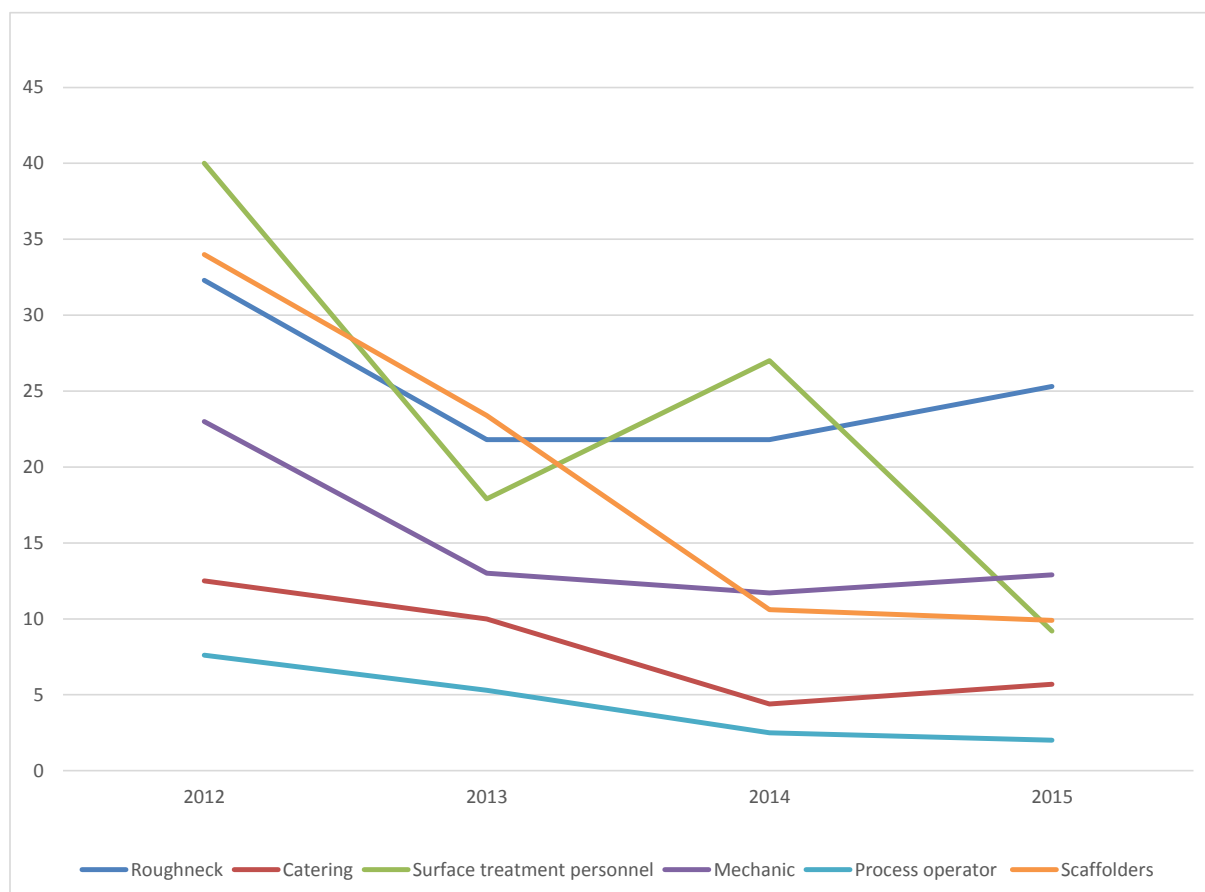


Figure 34 Proportion of work tasks for the individual employee groups on production facilities which as a whole were given red assessments in the period 2012-2015.

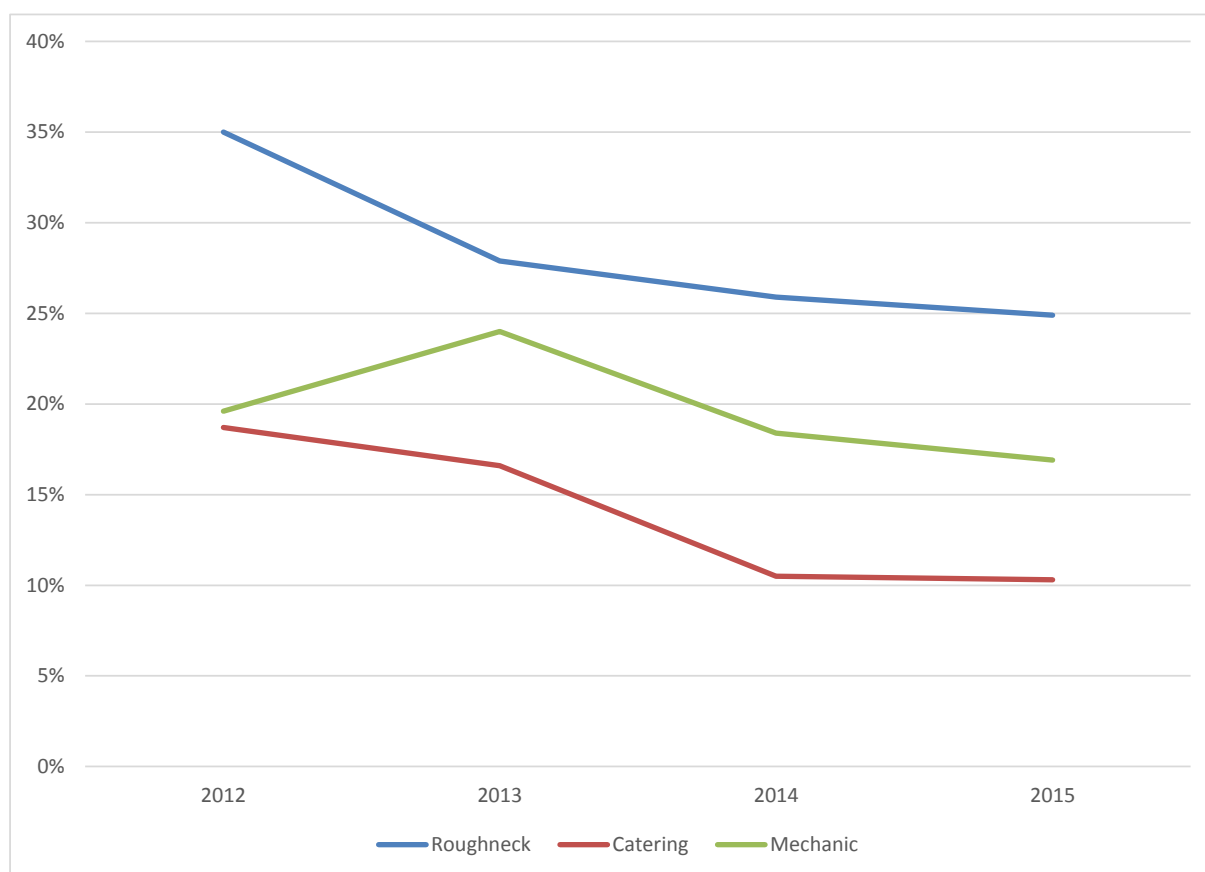


Figure 35 *Proportion of work tasks for the individual employee groups on mobile facilities which as a whole were given red assessments in the period 2012-2015.*

In general, the results show that the positive trend seen last year for most of the groups on production facilities has flattened out, and to some extent reversed. For production facilities, it is only surface treatment personnel who show a clear reduction in the proportion of work tasks assessed as red. For mobile facilities, the declining trend in 2014 and, to an extent 2013 and 2012, continues, with a reduction in the share of work tasks assessed as red in 2015.

The figures above show that roughnecks are the group which has most red overall assessments of work tasks for both production facilities and mobile facilities.

10. RNNP data in a late life perspective.

10.1 Introduction

A high and rising proportion of Norwegian petroleum activity is characterised by marginal profits because of production cutbacks and rising costs. This is connected with a diminution in the resource base and ageing of the facilities. This is an underlying trend that will be continually influenced and altered by various framework conditions, including the oil price and expectations for the oil price.

It is not possible to unambiguously define if a facility is in late life. Late life is a function of various factors of which low resource base, design life and age are among the most important. In addition, different aspects of the facility's technical condition are significant. Good maintenance management is therefore decisive for maintaining good operation of the facilities. Operational conditions and adequate facility-specific competence will also be important factors. The common perception in the industry is that late life begins once investments are no longer being made to increase the resource base or increase production efficiency.

The PSA has "late life safety" as one of its main priorities for 2015. The premise of this initiative is that regulatory requirements and prudent activities may more readily come under pressure in late life, and that it may be more difficult to sustain and improve the HSE level during this phase.

This study is based on a hypothesis that the HSE level is weakened on facilities in late life, and has a remit to investigate trends and patterns in the data collected through RNNP. There is an inherent assumption that any challenges in late life will be reflected in the indicators for the activities. At the same time, it is important to be clear that there are limitations as to what the RNNP data can tell us about risk contributors, and that the results of this study only show some parts of a wider picture.

The study is limited to production facilities and analysis of the following data sources.

- Major accidents (DFUs)
- Noise exposure harmful to hearing
- Personal injury
- Acute spills
- Barriers against major accidents
- Maintenance
- Questionnaire data

10.2 Methodology

10.2.1 Categorisation of facilities

One precondition for performing systematic comparison of facilities in late life and other facilities is the existence of a classification of facilities along the late life dimension. In this study, three categories are used: "late life", "mid-life" and "early life".

"Late life" is used for the facilities which are most clearly in their late life, while "early life" is used for the facilities which are absolutely clearly *not* in late life. The remaining facilities, which less obviously belong to one of these two categories, are placed in "mid-life". The introduction of an extra intermediate category makes all the categories more focused – with less variation within each category – which may make it easier to detect any differences between, in particular, early and late life.

In essence, the classification of facilities is based on two objective criteria:

- Remaining life
- Remaining recoverable reserves

In addition, a selection of highly experienced PSA specialists have made a generalised overall assessment that also takes account of general technical condition and organisational factors.

It is emphasised that the categorisation is intended only for analytical purposes in connection with this study. It is recognised that both the life phase categories and the facilities' placing therein are arguable. Very few of the facilities in the late life category are ones where there is no longer investment potential; most would, according to industry perceptions, not be in late life. The PSA will assess elaborating criteria for categorising late life facilities for use in other contexts.

10.2.2 Statistical analyses

The comparison of the different life phases is performed using standard statistical methods.

In many cases, there are obvious large differences between the phases, although it is concluded that such differences are not significant. This may appear to be self-contradictory but the explanation is that the data are very limited with few incidents or records of the data type in question, combined with relatively few facilities in each category. This makes the uncertainty very large, and makes it difficult to conclude that observed differences are real. For the questionnaires, the situation is the reverse; here there are often small differences between the phases, but it is nonetheless concluded that these differences are significant. This, too, may appear self-contradictory, but the explanation is that the groups are very large, making the uncertainty small and making it easier to conclude that observed differences are statistically significant.

10.2.3 Interviews

Interviews were performed with technical personnel on two facilities with different late life characteristics: an older facility with relatively large remaining resources, and a younger facility with a strongly diminishing resource base. The purpose of these interviews was twofold:

- To discuss results based on the analyses of RNNP data, in order to explain observed differences and, where appropriate, the lack of differences where they were expected.
- To discuss general issues and challenges associated with late life.

10.3 Analysis of RNNP data

10.3.1 Major accidents (DFUs)

In order to investigate whether the major accident potential is higher on facilities in late life than on other facilities, an analysis was made of defined hazard and accident situations (DFUs) that occurred in the period 2010 to 2014. The number of incidents in this period is however relatively low. A comparison between the different phases is only appropriate for those DFUs where the number of incidents is sufficiently high to make it meaningful to perform statistical analyses. In the period in question, this applies to hydrocarbon leaks (DFU1) and well control incidents (DFU3).

Overall, the analyses of the two DFUs do not support the general assumption that the HSE level on facilities in late life is weakened. Neither hydrocarbon leaks nor well control incidents occur significantly more frequently in late life.

10.3.2 Barriers against major accidents

In order to investigate the status in terms of barriers for facilities in late life, in advance of the analysis, hypotheses were formulated that late life facilities have a higher proportion of faults in barrier tests than the other two phases. The result of the analyses is presented below.

The results show that several types of valve on facilities in late life fail more often in tests than valves on other facilities. However, only one of the valve types analysed (DHSV) shows a significant difference between late life and the other two phases. A general explanation of increased valve problems in late life may be that older valves are more worn, and that various kinds of dirt and deposits have accumulated over time.

10.3.3 Maintenance

In order to investigate the status in terms of maintenance for facilities in late life, in advance of the analysis, hypotheses were formulated that late life facilities have a higher number of hours of backlog in preventive maintenance (PM) and outstanding corrective maintenance (CM), both total and HSE-critical, than the other two phases.

The RNNP data for maintenance show that this may be cause for concern for late-life developments, even if this is based on an overall consideration/average consideration across all facilities in late life. For individual facilities which have the greatest difficulties with the accumulation of backlogs/outstanding maintenance, there may be even greater cause for concern. These need to be followed up particularly carefully.

The causes of increased backlog/outstanding maintenance are complex and may include increased problems related to wear and ageing processes, manning and competence (over several generations of equipment, and local knowledge), spare parts and cost pressures. The concern is backed by the questionnaire data, where one of the questions/statements is "deficient maintenance has led to poorer safety" and where late life (or mid-life) comes out significantly worse than early life.

The interviews on selected facilities do not back this up to the same degree. In other words, in general the experience is not that safety is worse due to deficient maintenance. It was stated that there is good control of safety-critical maintenance, and that this is followed up closely. At the same time, it emerged that there are some pieces of "problem equipment" that require extra maintenance, and that more technical measures would have been implemented if the remaining life had been longer. Increased redundancy due to better process capacity in late life was also highlighted as a potentially favourable factor in terms of being able to carry out necessary maintenance. However, this is most relevant for production-related equipment.

Examples were given of recently replaced equipment (such as gas detectors), but also equipment that there are still problems with, and that are also awkward to maintain (such as certain types of valve). Assessment of measures is based on cost-benefit considerations and acceptable risk assessments. Retaining problem equipment in late life may be an acceptable solution as long as the performance requirements are satisfied. This will normally entail a requirement for increased PM (for example shorter test intervals) and more CM, due to higher failure rates. There is therefore a trade-off to be made between investment in new equipment and increased operating costs on old equipment. It is not self-evident that it is profitable to retain old equipment, even in late life.

10.3.4 Personal injuries

Over the long term, the frequency of personal injuries on production facilities has shown a downward trend. In recent years, the injury rate has been at around 8 injuries per million working hours. In order to investigate whether the extent of personal injuries is greater on late life facilities than on mid-life and early life facilities, a comparative analysis was performed of the incidence of both personal injuries and *serious* personal injuries in the period 2010 to 2014. Personal injuries are defined here as injuries which cause fatality, absence into the next shift, relocation, incapacity for work exceeding 3 days, hospital treatment or medical treatment. *Serious* personal injuries are defined in the guidelines to the Management Regulations Section 31, which definition is used as the basis for classifying serious personal injuries.

Overall, the analyses of injuries and serious personal injuries do not support the general assumption that the HSE level on facilities in late life is weakened.

10.3.5 Noise exposure harmful to hearing

In order to investigate whether the noise level is higher on late life facilities than on other facilities, an analysis was performed in 2014 of the indicator for noise exposure. The indicator is calculated on the basis of noise level and duration of presence in the noisiest areas and a contribution from noisy work operations. In 2014, noise data were reported from 43 production facilities, of which 42 were assignable to early life, mid-life or late life.

The analyses of the noise indicator do not provide evidence for higher noise levels in late life, nor do the answers concerning perceived noise in the questionnaire-based survey indicate that the facilities categorised as late life are perceived to be noisier than other facilities or support the general assumption that the HSE level on late life facilities is weakened.

10.3.6 Acute spills

In the last 15 years, the number of acute crude oil spills has displayed a clear downward trend. However, the total spill volume does not show a corresponding reduction. This is due to individual incidents of spills exceeding 10 m³. At the same time, both the number of acute crude spills and the spill volumes vary considerably over time between the different facilities.

In order to investigate whether the variation in occurrences of acute spills is ascribable to the phase of life of the different facilities, a comparative analysis has been performed of early life, mid-life and late life facilities for both numbers and volumes of acute crude oil spills in the period 2010 to 2014. In this period, a total of 111 acute spills and a combined spill volume of 220 m³ were recorded for facilities classified as early life, mid-life or late life. In the analyses, the numbers and volumes were normalised against working hours. Furthermore, facilities where crude oil spills are impossible for natural reasons are excluded from the analyses.

Overall, the analyses of numbers and volumes of acute crude oil spills do not support the general assumption that the HSE level on facilities in late life is weakened.

10.3.7 Questionnaire data

In advance of the analyses of questionnaire data, it was assumed that HSE conditions would be assessed more negatively on late life facilities than on early and mid-life facilities.

Concerning *perceived physical, chemical and ergonomic working environment*, the analyses only provide very limited support for the general assumption that the HSE level on facilities in late life is weakened.

For *perceived risk of oil and gas leaks, blowouts, spills and collapses*, the analyses only provide very limited support for the general assumption that the HSE level on facilities in late life is weakened.

Regarding questions linked to perceived safety climate, the results indicate that the handling of safety is not perceived to be weaker among employees who work on late life facilities compared with other facilities. The results point rather in the other direction, despite marginal differences.

10.4 Discussion

One objective of this study was to investigate any differences in HSE level as expressed in RNNP data for late life facilities compared with other facilities. One key trait of the results is that the hypotheses concerning weakened HSE level on facilities in late life are largely

not confirmed by the data. Furthermore, in cases where significant differences are actually demonstrated, facilities in late life do not come out systematically worse or better than other facilities.

It is important to underline that a failure to identify differences between late life facilities and other facilities does not necessarily preclude such differences, but rather that the data and methodology are not capable of detecting this. Given this premise, possible causes for not detecting differences could be:

- **Lack of data.** A number of categories of incident data, especially risk indicators for major accidents and several types of barrier, have very few recorded incidents. This makes it difficult to identify the significance of observed differences.
- **Low data quality.** RNNP data are reported using the same template from all facilities and quality-assured at several stages, but the quality of the data is variable. Variation in the way the data are reported will give rise to variation in the actual data, and the greater the variation between facilities in the same life phase, the more difficult it is to identify the significance of differences between the life phases.
- **Atypical facilities.** In the averaging, all facilities are weighted equally (after any normalisation). In earlier RNNP reports, notably for barriers and hydrocarbon leaks, it has been pointed out that some facilities stand out strongly either positively or negatively and may therefore be atypical compared with other facilities within a life phase. Such facilities will therefore increase the variation in the life phase group and complicate the identification of significant differences between the phases. Comparisons have been made after exclusion of the most extreme cases, but these have not affected the conclusions.
- **Imprecise life phase categorisation.** The categorisation into early, mid- and late life is based primarily on criteria such as remaining life and remaining recoverable resources, but also assessments of technical condition and organisational factors. It is not certain that the chosen categorisation fully corresponds with the "real" life phase scenario on the NCS. The greatest uncertainty concerns the mid-life phase, which consists of the facilities left over after categorising those which are clearly in the late life phase and those which are clearly not.

By way of introduction, a range of factors were mentioned that support the general assumption of a weakened HSE level on facilities in late life. Likewise, other factors could be mentioned which might be imagined to *contradict* this assumption, and thereby help to explain why significant differences between the life phases are not found. Important factors which may be seen as contradicting the hypotheses are:

- In late life, there is likely to be very good knowledge of processes and equipment, with expertise accumulated over a long time.
- Similarly in late life, there may be excellent competence concerning local conditions relating to wells and geology.
- There will often be reduced pressure and low volumes in late life, which contribute to lower risk exposure.
- Most fields with late life facilities still have considerable investment potential in respect of new drilling targets, phasing in of additional resources, modifications aimed at increasing production efficiency, and so forth. This probably contributes to maintaining technical integrity.
- There appears to be a low threshold for replacing safety-critical equipment when necessary.
- A focus on continuous improvement; it can be argued that each facility is developed into an increasingly better version of itself through improvement work (campaigns to reduce gas leaks, different causal analyses, improved procedures/routines, adaptation of equipment to local processing conditions, etc.).

10.5 Conclusion

Based on the quantitative analysis of RRNP data and information from interviews, the study has the following conclusions.

- Using the criteria on which the analysis is based, it can be claimed that around one third of the facilities on the NCS are in varying degrees of late life. The transition to late life generally occurs gradually, and it is difficult to define exactly when it happens.
- The data collected via RRNP provide little support for the hypothesis that HSE conditions are poorer on late life facilities compared with other facilities. Nor do interviews support such a correlation.
- For some barriers, especially valves, we see a tendency for increased failure rate on late life facilities.
- Within the area of maintenance, we see that both the total volume of maintenance and backlog of maintenance increase in late life. This applies to both preventive and corrective maintenance. The situation is also the same when looking only at HSE-critical maintenance.
- In the interviews, it emerged that late life facilities may make operational and maintenance-related changes that can potentially affect regularity and non-critical systems. However, such changes will only be made following careful assessment and without being at the cost of safety.
- In general, it may appear that facilities in late life are able to take the necessary steps to maintain the safety level.

The "late life safety" initiative is relatively new, and it is important to maintain focus on the area so that both the facilities and the PSA can draw lessons for the benefit of safety. This study has identified few significant differences between the phases, which illustrates the complexity of the activity. There may be many factors that affect the HSE level negatively and positively, and some of these are discussed above. It is possible that other types of investigation – quantitative or qualitative – would be better suited to identifying late life challenges. The analysis and the factual basis it presents is nonetheless an important tool in future work on ensuring late life safety.

A persistently low oil price is an external framework condition that may reinforce the underlying late life trend and accelerate decommissioning dates. The study's data derive from the period before the fall in the oil price; it is conceivable that a similar study performed after some years of low oil prices would have yielded results more in accord with the hypotheses.

11. Other indicators

11.1 DFU20 Crane and lifting operations

To improve the usefulness of the data reported in previous years under DFU21 falling objects, from 2015 a new category has been created, DFU20 crane and lifting operations. DFU20 crane and lifting operations covers incidents involving lifting equipment and its use which lead to personal injury or harm to equipment or the environment.

In addition to incidents that were previously reported under DFU21 falling objects (crane and lifting operations that cause falling objects), DFU20 crane and lifting operations also includes incidents that do not involve falling objects (for example, swinging loads that cause crush injuries). This type of incident has not previously been part of RNNP.

The operators were asked to report on incidents from 2013-2015, so that from the creation of DFU20 crane and lifting operations there was already an historical overview of trends. Since the time series only comprises three years of data, the analysis focuses both on the three years combined where appropriate, and a comparison between the three years where this is appropriate. The new DFU has not yet been fully incorporated by all the operators, which means that there is some uncertainty concerning the distribution of data received.

In the period 2013-2015, an average of 74 incidents were reported to RNNP. In 2015, 63 incidents were reported, which is on a par with the 62 incidents from 2014.

An analysis was conducted to categorise the incidents in accordance with initiating 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.

Figure 36 shows percentage distribution of incidents broken down by type of lifting equipment for 2013-2015. For the three types Other Lifting Equipment, Lifting Equipment in the Drilling Modules and Offshore Cranes which constitute the majority of the incidents, it can be seen that there are large differences within the different categories for individual years. This makes it difficult to see any trends. For Other Lifting Equipment and Lifting Equipment in the Drilling Modules, it is primarily work processes involving the use of lifting equipment that constitute most of the incidents. Regarding Offshore Cranes, most of the incidents concern the use of lifting internally on the facility or between the facility and a vessel.

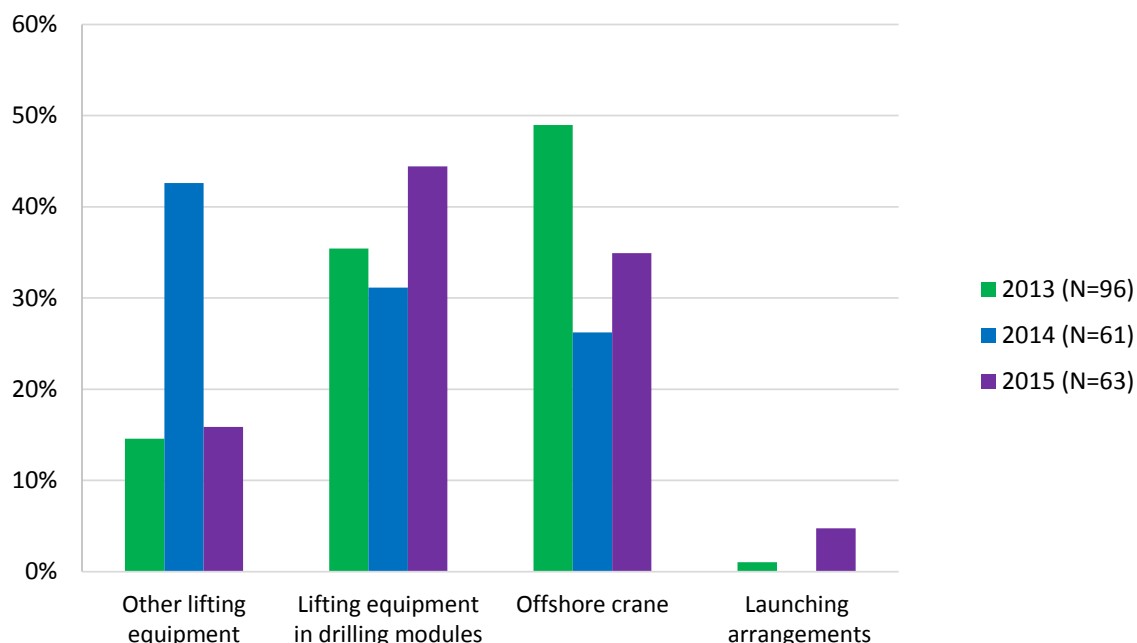


Figure 36 Percentage distribution of incidents per year for the different categories of lifting equipment for 2013-2015

Incidents linked to crane and lifting operations have a greater potential for causing personal injury than incidents linked to falling objects. There is accordingly a greater proportion of incidents causing personal injury under DFU20 crane and lifting operations than under DFU21 falling objects. Out of a total of 220 incidents reported for the period 2013-2015 under DFU20 crane and lifting operations, 33 of the incidents caused personal injury, constituting 15% of the incidents. After normalising personal injuries against number of working hours on the NCS (excluding administration and catering), it emerges that there is a slight decline in the proportion of incidents involving personal injury in the period 2013-2015, as shown in Figure 37.

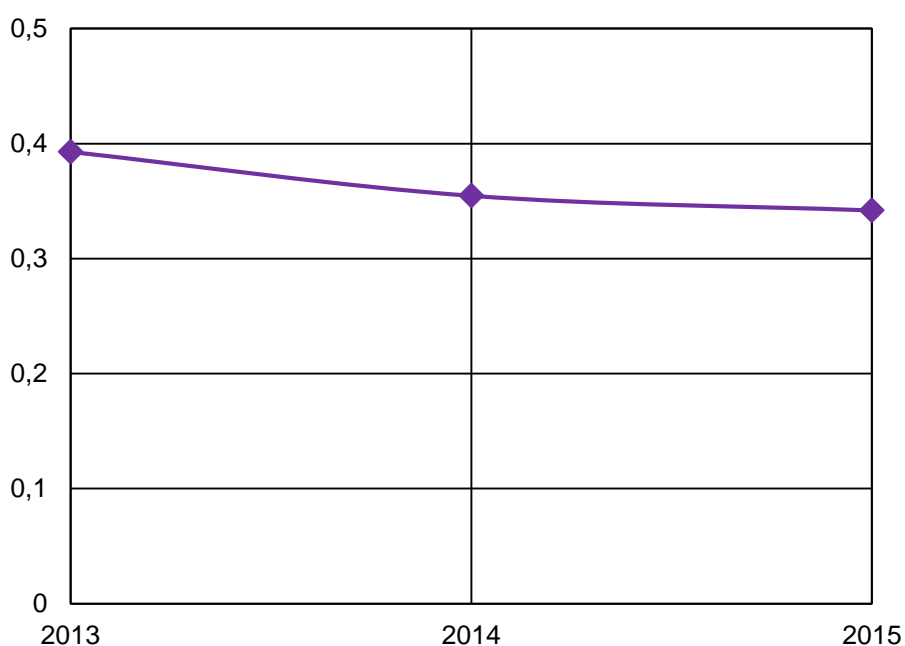


Figure 37 Number of personal injuries per year for incidents involving crane and lifting operations normalised against working hours (millions)

11.2 DFU21 Falling objects

The introduction of the new DFU20 crane and lifting operations category has caused changes for DFU21 falling objects, and hence incidents from 2013. During the period 2013-2015, an average of 168 incidents related to falling objects were reported to RNNP each year. In 2015, a total of 153 incidents were reported, somewhat lower than the previous year's reporting of 177 incidents.

An analysis was conducted to categorise the incidents in accordance with initiating causes. The period 2006-2014 was assessed primarily. The categorisation was performed 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 with falling objects.

Figure 38 shows the distribution of incidents in main categories of work processes for 2013-2015. For 2015, the causal distribution is non-uniform for the different work processes, but there is one commonality since category B is the largest causal category for all work processes.

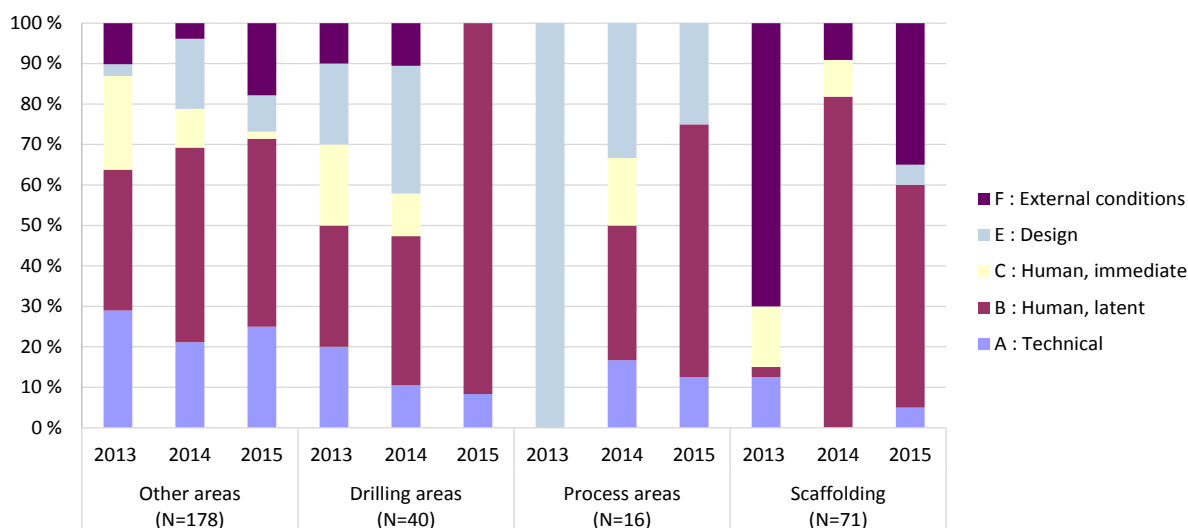


Figure 38 Causes of falling objects distributed by work processes per year 2013-2015

Figure 39 presents a detailed display of the causes of falling objects in drilling-related work processes. The data for these work processes include registered incidents dating back to 2013. Categories B2 – Inadequate securing and B3 – Other latent hazard constitute the largest share of the incidents.

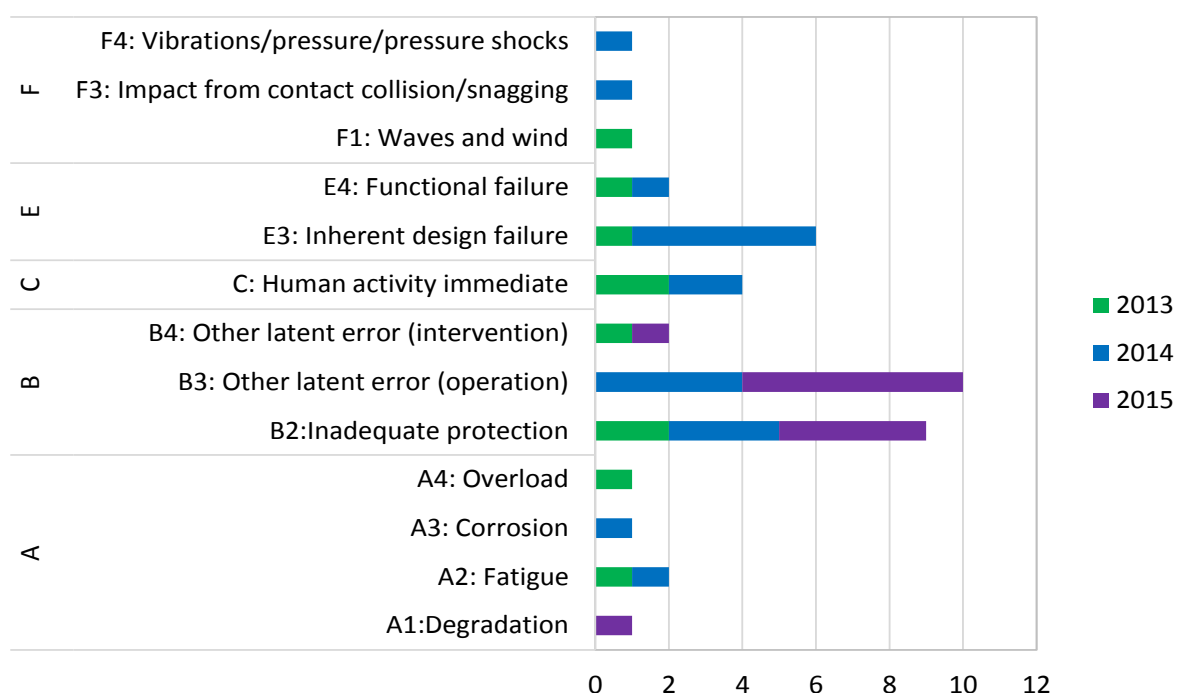


Figure 39 Causes of falling objects distributed by drilling-related work processes per year 2013-2015

11.3 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 Table 1.

12. Definitions and abbreviations

12.1 Definitions

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

12.2 Abbreviations

For a detailed list of abbreviations, see PSA, 2016a. Trends in the risk level on the Norwegian Continental Shelf, Main report, 28/04/2016. The most important abbreviations in this report are:

CM	Corrective maintenance
CODAM	Database for damage to structures and subsea facilities
DDRS/CDRS	Database for drilling and well operations
DFU	Defined hazard and accident situations
GM	Metacentric height
HSE	Health, safety and environment
KPI	Key performance indicator
NPD	Norwegian Petroleum Directorate
PM	Preventive maintenance
PSA	Petroleum Safety Authority Norway
STAMI	National Institute of Occupational Health
WIF	Well Integrity Forum

13. References

Detailed reference lists can be found in the main reports:

PSA, 2016a. Trends in the risk level on the Norwegian Continental Shelf, Main report, 28/04/2016

PSA, 2016b. Developments in the risk level - onshore facilities in the Norwegian petroleum activities, 28/04/2016