

SUMMARY REPORT 2014 - NORWEGIAN CONTINENTAL SHELF

# TRENDS IN RISK LEVEL

IN THE PETROLEUM ACTIVITY



PETROLEUM SAFETY AUTHORITY  
NORWAY



## 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 toward 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 in combination with data from the Norwegian Oil Industry Association's EPIM database (formerly Environment 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 Due to the data collection period in EPIM, the RNNP report on acute spills will not be published until autumn.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, 24 April 2015

Finn Carlsen,  
Director for Professional Competence, PSA

## CONTENTS

1. Objective and limitations.....	1
1.1 Purpose .....	1
1.2 Objective .....	1
1.3 Key limitations.....	1
2. Conclusions .....	3
3. Execution.....	7
3.1 Execution of the work .....	7
3.2 Use of risk indicators .....	8
3.3 Developments in the activity level .....	8
3.4 Documentation .....	10
4. Scope.....	11
5. Status and trends - DFU12, helicopter incidents.....	12
5.1 Activity indicators.....	12
5.2 Incident indicators.....	13
6. Status and trends – indicators for major accidents on facilities .....	17
6.1 DFUs associated with major accident risk .....	17
6.2 Risk indicators for major accidents .....	17
6.3 Total indicator for major accidents .....	23
7. Status and trends – barriers against major accidents.....	25
7.1 Barriers in the production and process facilities.....	25
7.2 Barriers associated with maritime systems .....	27
7.3 Indicators for maintenance management .....	27
8. Status and trends – work accidents involving fatalities and serious personal injuries.....	31
8.1 Serious personal injuries, production facilities.....	31
8.2 Serious personal injuries, mobile facilities .....	32
8.3 Comparison of accident statistics between the UK and Norwegian shelves .....	33
9. Risk indicators – noise, chemical working environment and ergonomics .....	34
9.1 Noise exposure harmful to hearing .....	34
9.2 Chemical working environment .....	36
9.3 Ergonomics .....	38
10. At-risks groups in the petroleum industry – analyses of risk exposure using questionnaire data .....	41
10.1 Selection and methodology .....	41
10.2 Background variables, factors and outcome measures .....	41
10.3 Construction of variable – At-risk positions versus other positions .....	43
10.4 Results .....	43
11. Other indicators .....	45
11.1 DFU21 Falling objects .....	45
11.2 Other DFU.....	46
12. Definitions and abbreviations.....	47
12.1 Definitions.....	47
12.2 Abbreviations .....	47
13. References .....	48

## List of tables

Table 1	Overview of DFUs and data sources .....	9
Table 2	General calculations and comparison with industry standards for barrier elements .....	27

## List of figures

Figure 1	Trend in activity level, production .....	9
Figure 2	Trend in activity level, exploration .....	10
Figure 3	Volume of transport service and shuttle traffic, person flight hours and flight hours, 2000-2014 .....	12
Figure 4	Incident indicator 1, incidents with little or medium remaining safety margin, 2006-2014 .....	14
Figure 5	Helideck factors, 2008-2014 .....	15
Figure 6	ATM aspects, 2008-2014 .....	16
Figure 7	Bird strikes, 2008-2014 .....	16
Figure 8	Reported DFUs (1-11) by categories .....	17
Figure 9	Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2014 .....	18
Figure 10	Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2014, weighted according to risk potential .....	18
Figure 11	Trend, leaks, normalised against facility years, manned production facilities .....	19
Figure 12	Average leak frequency per facility year, 2010-2014 .....	19
Figure 13	Well incidents by severity per 100 wells drilled, for exploration and production drilling .....	20
Figure 14	Distribution of well control incidents by areas, 2000-2014 .....	20
Figure 15	Well categories - red, orange, yellow and green, 2014 .....	21
Figure 16	Development in well categories, 2009-2014 .....	21
Figure 17	Number of incidents involving serious damage to risers & pipelines within the safety zone, 2000-2014 .....	22
Figure 18	Number of serious incidents and incidents involving damage to structures and maritime systems which conform to the criteria for DFU8 .....	23
Figure 19	Total indicator, production facilities, normalised against working hours, annual values and three-year rolling average .....	24
Figure 20	Total indicator, mobile facilities, normalised against working hours, annual values and three-year rolling average .....	24
Figure 21	Mean percentage of failures for selected barrier elements, 2014 .....	25
Figure 22	Percentage of failures for riser ESD valves (closure test) .....	26
Figure 23	Trend 2010-2014 of total backlog of PM per year for production facilities on the NCS .....	28
Figure 24	Trend 2010-2014 of total volume of outstanding CM per year for production facilities on the NCS .....	29
Figure 25	Trend in hours of work in the period 2010-2014. Note: Not all the participants supplied figures for 2010 .....	30
Figure 26	Serious personal injuries on production facilities relative to working hours .....	32
Figure 27	Serious personal injuries per million working hours, mobile facilities .....	32
Figure 28	Average noise exposure for position categories and facility type, 2014 .....	34
Figure 29	Plans for risk-reducing measures .....	35
Figure 30	Indicator for the chemical spectrum's risk profile – fixed production facilities .....	36
Figure 31	Indicator for the chemical spectrum's risk profile – mobile facilities .....	37
Figure 32	Management of risk of chemical exposure for mobile and production facilities .....	38
Figure 33	Proportion of work tasks for the individual employee groups on production facilities which as a whole were given red assessments in the period 2012-2014. ....	39
Figure 34	Proportion of work tasks for the individual employee groups on mobile facilities which as a whole were given red assessments in the period 2012-2014. ....	40

Figure 35	Triggering causes by main categories of work processes, 2002-2014.....	45
Figure 36	Triggering causes by detailed categories of work processes, 2002-2014.....	46

## Part 1: Objective and conclusions

### 1. Objective and limitations

#### 1.1 Purpose

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. It is important to establish a procedure for measuring the impact of the industry's overall safety work. 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 certain key HSE factors.

The Petroleum Safety Authority Norway wishes to create a 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 Objective

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 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, and includes major accidents, occupational accidents and working environment factors. Both qualitative and quantitative indicators are used. A questionnaire-based survey is conducted under the auspices of RNNP every other year. No such survey was conducted for the presented report. A multi-method study was performed to examine at-risk groups in the petroleum industry through the use of questionnaire data from RNNP 2001-2013.

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 2015.

## 2. Conclusions

In this work, the PSA seeks to measure trends in the risk level as regards safety, the working environment and the external environment<sup>1</sup>, by using a number of relevant indicators. The basis for the assessment is the triangulation principle, i.e. using multiple measuring instruments to measure the same phenomenon; in this case, trends 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 comprehensive 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
  - Chemical working environment
  - Noise exposure harmful to hearing
  - Ergonomic factors
- Qualitative assessments for selected areas.

In 2014, seven hydrocarbon leaks exceeding 0.1 kg/s were recorded. This is the second-lowest number recorded in the period (2000-2014). The level in 2014 is comparable with that in 2012, when there were six leaks. One leak in the largest category, above 10 kg/s (20.8 kg/s), and one in the 1-10 kg/s category were recorded in 2014. The other leaks were between 0.1 and 1 kg/s. No leaks were assessed to have had an especially large potential. This means that the risk contribution in 2014 is the lowest recorded in the period 2000-2014. All the hydrocarbon leaks  $\geq 0.1$  kg/s in 2014 were associated with one operator.

17 well control incidents were recorded in 2014, 16 in the lowest risk category (level 3) and one in the medium risk category (level 2). This is a slight increase from 2013 when 13 incidents were recorded. When assessing the number of incidents against the level of activity, there were increases in both production drilling and exploration drilling. Within exploration drilling, the number of incidents in relation to the activity level varies to the greatest extent, and the level in 2014 lies above the average for the period 2000-2014. In 2014, the risk indicator associated with well control incidents is relatively low compared with previous years, which can be explained by the fact that the majority of incidents in 2014 are at level 3, low severity.

Only one ship was registered on a collision course in 2014, and this is the lowest recorded for the period 1996-2014. Assessed against the number of facilities monitored from Sandsli, a significant reduction was observed compared with the period 2005-2013. Here the impact of sea areas around the facilities being controlled by dedicated traffic centres must be ascribed as a clear causal factor.

In 2014, there were two collisions between a facility and a 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, however, been in the severe category.

---

<sup>1</sup> Data collected through RNNP is used along with data from the EPIM database (formerly Environment Web (EW)) to assess acute spills to sea. The results will be presented in a separate report to be published in the autumn.



Incidents associated with structures and maritime systems showed an increase from three incidents in 2010 to 13 in 2012. In 2013, there were 10 incidents, while in 2014 there was a decrease, to seven incidents. One of the incidents relates to anchoring systems, one relates to DP systems and five concern fractures.

No leaks from risers or pipelines were reported in 2014. There was one report of a leakage categorised as serious from a subsea installation within the safety zone. In 2014, there were two reported incidents of serious damage to pipelines and risers. The number of incidents has fallen since a peak in 2011, and it is still flexible risers that dominate the damage scenario.

The other indicators reflecting near-misses with major accident potential show a stable level with relatively minor changes from 2013 to 2014.

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 in 2014 is at its lowest level for the period since 2000. This is due to a fall in the number of incidents, and the fact that none of them had a particularly large inherent potential for causing many fatalities if they had developed. A fall is observed in the total indicator (3-year rolling average), both for production facilities and mobile facilities.

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 small decline in the number of incidents from 2013 to 2014. However, the incident in 2014 is assessed as having had "little remaining safety margin", whereas in the five preceding years only incidents with "medium remaining safety margin" were recorded. For 2014, the incident relates to a torch left in the immediate vicinity of the gearbox of an S-92.

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 level differences between the facilities. For certain barrier systems, some facilities have not achieved the expected industry level.

As in the previous year's RNNP report, the mean percentage of failures for 2014 and the mean percentage of failures for 2002-2014 for riser ESDVs, blowdown valves (BDVs) and deluge valves are above the expected industry level. A new factor in 2014 is that DHSVs have exceeded the industry standard both in terms of mean percentage of failures for 2014 and mean percentage of failures for 2002-2014. The same is true of mean percentage of failures of wing and master valves which were somewhat above the industry standard in 2014. At facility level, it is observed that individual facilities have occasionally large deviations from expected levels over several years. This may be an indication of weakened barriers if the weakness is not compensated for. There are significant differences between operators in terms of whether they are within expected industry levels for the different barrier elements.

When comparing mean percentages of failures for the barrier elements in 2014 with equivalent 2013 figures, an improvement in most of the barrier elements is observable. As in the previous year's RNNP report, it can be seen that the mean percentage of failures for 2014, as well as the average for the period 2002-2014, of the riser ESDV, blowdown valve (BDV) and deluge valve barrier elements are worse than the industry standard. At facility level, it is observed that individual facilities have occasionally large deviations from expected levels over several years. This may be an indication of weakened barriers if the weakness is not compensated for. There are significant differences between operators in terms of whether they are within expected industry levels for the different barrier elements. 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 has been collected for five years. Maintenance management data for the production facilities for 2014 shows a considerable fall in outstanding corrective maintenance relative to 2012 and 2013, although the number of hours of corrective maintenance performed has not increased in the same period of time. The reduction was due primarily to two major participants on the NCS. On request (audit), one of the participants explained that clearing out and quality-assuring the CM portfolio contributed significantly to the reduction.

For mobile facilities, there is, in our view, greater uncertainty associated with the maintenance management data. Data collected for 2014 shows progress on some facilities in terms of the number of labelled and classified items of equipment. In other respects, the 2014 scenario is unchanged from previous years. Due to little change in reported maintenance management data for some of the mobile facilities, direct contact with the participants was made last year through the Norwegian Shipowners' Association. This dialogue is being continued in 2015.

In the long term, there has been a steady downward trend in the frequency of serious personal injuries relative to the peak in 2005. There was a small increase in the serious personal injury rate per million working hours from 0.48 in 2013 up to 0.53 in 2014. The frequency is just below the expected level based on the 10 preceding years (0.56). 2014 is the first year in which no injuries were recorded among operator employees on production facilities. There was an increase in 2014 for contractor employees on production facilities compared with 2013. The frequency rose from 0.32 to 0.65 injuries per million working hours in 2014. The injury rate for contractor employees in 2014 was within the expected value based on the 10 preceding years. The injury rate on mobile facilities showed a slight increase in 2014 compared with the two preceding years, but was still considerably lower than the level in the period 2004-2008.

The noise indicator shows an improvement for ten out of 11 position categories from 2013 to 2014. The position category of surface treatment personnel shows a slight deterioration. 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. Permanent installations 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 the facilities for both permanent and mobile installations. For mobile facilities, there is a marked increase in the number of chemicals with health hazard classification from 2013 to 2014. 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 permanent installations, and shaker operators' short-term assessments and surface treatment personnel's full-shift assessments are highest for mobile facilities.

Indicators for ergonomics show a generally positive trend for production facilities in terms of red-score assessments of work tasks taken as a whole from 2012 to 2014 for all groups. Surface treatment personnel saw a decline from 2012 to 2013, followed by an increase from 2013 to 2014, but still well below the 2012 level. Surface treatment personnel are the group that had most work tasks in 2014 that, as a whole, were assessed as red. On mobile facilities the reports also show a weak positive trend for all employee groups.

In terms of overall assessment of working environment factors on production facilities, it is working position and lifting/carrying that constitute the greatest risks for roughnecks, mechanics and scaffolders. Compared with 2013, an increase was recorded in red overall assessments for lifting/carrying for roughnecks and mechanics. For surface treatment personnel, it is working position and repetition that constitute the greatest risk in 2014, but there are fewer red assessments overall for working position, repetition and hand-held tools in 2014 than in 2013. On mobile facilities, it is roughnecks who have the greatest exposure among the group, and it is lifting/carrying and working position that have most red assessments. Compared with 2013, there were only minor changes in the reporting for the different employee groups. For employee groups on mobile facilities as a whole, lower risks were reported for two or more working environment factors.

In 2014, the Petroleum Safety Authority Norway instigated a multi-method study to examine at-risk groups in the petroleum industry through the use of questionnaire data from RNNP 2001-2013. The aim was to investigate how risk and different HSE conditions associated with the physical and psycho-social working environments and safety climate vary over time in the different groups. The results showed relationships between self-reporting of all HSE conditions and self-reported negative outcomes such as: work accidents involving personal injury, work-related sickness absence and health complaints caused by the work situation. Furthermore, some positions were more at risk than others, young people more than older people, and there were differences between operators' and contractors' employees, between temporary and permanent staff, and between Norwegian and non-Norwegian personnel. There were also strong relationships between experiencing reorganisation, downsizing and redundancy processes, and the likelihood of being at risk of a self-reported work accident involving personal injury. From 2009 onwards, the results for at-risk groups show a clear negative trend in this area. This shows that the task of improving the situation for at-risk groups is not on target, and these are also important results inasmuch as the industry is now in a phase of considerable change.

The survey also included a qualitative section with group interviews with a total of 6 respondents from the contractor and operator side, employee representatives and technical experts. Some of the topics that emerged from the interviews were the importance of establishing good forums for the exchange of experience, being focused on late effects relating to exposure at work, challenges associated with new technology and readiness to invest, contractual conditions, hired labour in a tight labour market and the loss of key expertise during recession. The focus on at-risk groups has led to work to improve their situation being placed on the agendas of industry participants. The Norwegian Oil and Gas Association's noise project was mentioned as a positive example. Also emphasised was the importance of having a driving force for improving the conditions of at-risk groups, so that the active efforts to improve the work situation for these groups are not lost.

## Part 2: Execution and scope

### 3. Execution

The work in 2014 is a continuation of previous years' activities, carried out in the period 2000-2014; see NPD (2001), NPD (2002), NPD (2003), PSA (2004), PSA (2005), PSA (2006), PSA (2007), PSA (2008), PSA (2009), PSA (2010), PSA (2011), PSA (2013) and PSA (2014). (Complete references are provided in the main report, as well as at [www.ptil.no/rnnp](http://www.ptil.no/rnnp)). This year we have continued the general principles and have further developed the reporting with special emphasis on:

- The work on analysing and evaluating data related to defined hazard and accident situations has been continued, both on the facilities and for helicopter transport.
- A considerable volume of empirical data on barriers against major accidents was collected and analysed in the same way as in the period 2003-2013. 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.
- A multi-method study was performed to examine at-risk groups in the petroleum industry through the use of questionnaire data from RNNP 2001-2013.
- Data from onshore facilities has 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 2015. 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 |
| • Civil Aviation Authority Norway:             | Responsible for reporting public data regarding helicopter activities and quality assurance of data, analyses and conclusions  |
| • 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, Beate R. Wagnild, Robert Ekle, Grethe Lillehammer, Aud Børsting, Tea S. Lian, Reidun Værnes, Trond Stillaug Johansen, Asbjørn Gilberg, Kai Arne Jenssen, Knut-Arne Vik and Geir Drage Berentsen, Safetec
- Anita Øren, Tony Kråkenes, Ragnar Rosness and Stian Antonsen, SINTEF
- The PSA's working group consists of: Øyvind Lauridsen, Mette Vintermyr, Arne Kvitrud, Trond Sundby, Hilde Nilsen, Inger Danielsen, Elisabeth Lootz, Sigvart Zachariassen, Brit Gullesen, 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:

- Erik Hamremoen, Norwegian Oil and Gas Association, represented by LFE
- Egil Bjelland, Morten Haugseng, CHC Helikopter Service
- Kjetil Heradstveit, Tom Idar Finnesand, Caspar Smith, Inge Løland, Sten Idar Nilssen, Bristow Norway AS
- Torgny Almhjell, Norsk Helikopterservice AS
- Dag Johan Sætre, Offshore AS

Numerous other people have also contributed to the work.

### 3.2 Use of risk indicators

Data has 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 has 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 19 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 1996 to 2014 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.

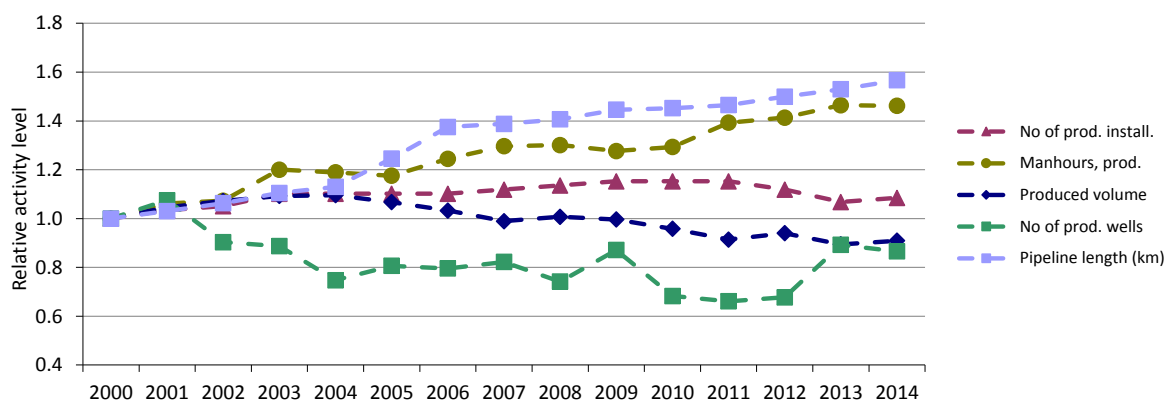
**Table 1 Overview of DFUs and data sources**

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

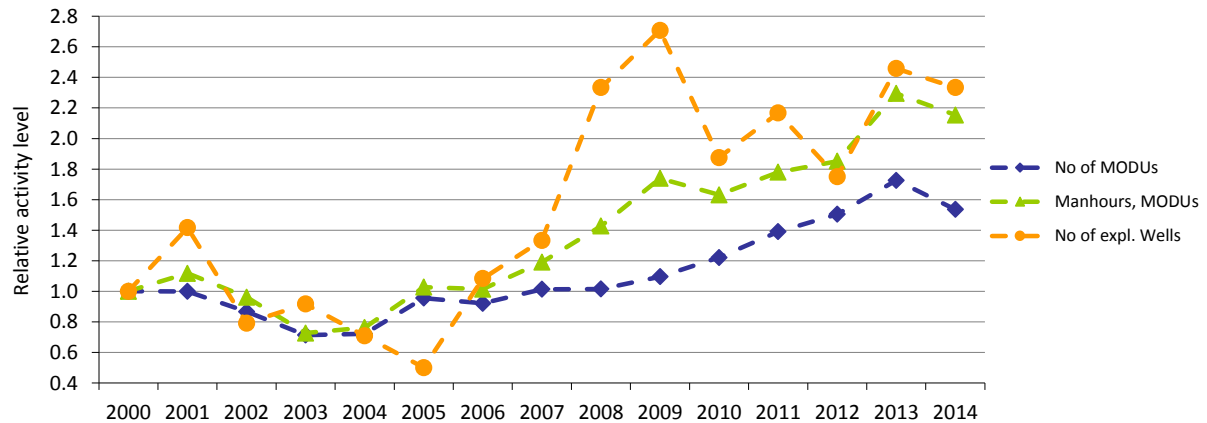
\* Data collection is carried out in cooperation with the operating companies

\* Also includes wellstream pipeline, loading buoy and loading hose where relevant.

This is a fall in total working hours for production facilities of around 2.2% compared with the previous year. Nonetheless, the number of working hours in 2014 is the second-highest recorded in the period, and the total number of working hours in the years 2013 and 2014 is at a relatively high level compared with the period 2000-2012. A presentation of DFUs or 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 2014 (Norwegian and English versions)
- Main report – the Norwegian Continental Shelf for the year 2014
- Report for onshore facilities for the year 2014
- Report for acute spills to sea for the Norwegian Continental Shelf 2014, to be published in the autumn of 2015
- Methodological report, 2014

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

#### 4. Scope

This social science analysis consists of the questionnaire-based survey which is repeated every other year (not in 2014) and a study examining at-risk groups in the petroleum industry through the use of questionnaire data from RNNP 2001-2013.

The methods for statistical analyses have been maintained from previous years, with only minor changes.



## 5. Status and trends - DFU12, helicopter incidents

The cooperation with the Civil Aviation Authority and the helicopter operators was continued in 2014. 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, 2015a) contains additional information about the scope, constraints and definitions. The last major accident to result in fatalities on the NCS was in September 1997 in connection with the helicopter accident outside Brønnøysund.

In 2014, there was one fatal incident in connection with transporting a mentally unstable person. The patient was medically cleared for transport ashore by SAR helicopter by a doctor and nurse, but jumped out of an emergency exit/window at a height of 2,000 feet roughly 10 minutes before landing. This incident is not included in any of the indicators apart from incident indicator 2.

Worldwide, however, there have been several fatal accidents linked to helicopter traffic in recent years. In the last five years, there have been five helicopter accidents on the UK-side of the North Sea, two of them fatal.

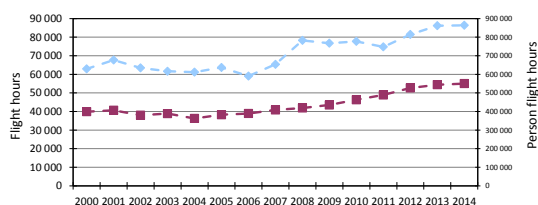
In 2012, there were two emergency landings on the sea in the UK sector, and one controlled emergency landing on a facility in the Norwegian sector. All of these occurred with the EC225 Super Puma helicopter type. This led to restrictions on the use of this helicopter type while the manufacturer, with support from the industry, worked to establish the cause. Modification of an axle in the gearbox and the introduction of a comprehensive technical and operational monitoring programme allowed the EC225 fleet to continue operating until the gearboxes were replaced. At the time of writing, the gearboxes of the entire fleet have been replaced.

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.

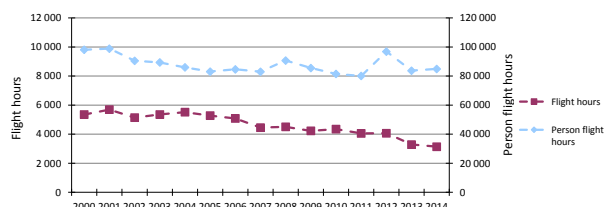
### 5.1 Activity indicators

Figure 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 2000-2014. For the transport service, there has been an increase since 2004. There was a slight reduction in the volume of shuttle traffic for the period as a whole. In 2013, a marked reduction was reported in the number of flight hours (around 19.2%) and person flight hours (around 13.6%) compared with 2012. This appears to have stabilised somewhat in 2014 with a reduction in the number of flight hours (around 4.5%) and an increase in the number of person flight hours (around 1.4%).

TRANSPORT SERVICE



SHUTTLE TRAFFIC



**Figure 3 Volume of transport service and shuttle traffic, person flight hours and flight hours, 2000-2014**

Activity indicator 1, the annual volume of transport service, must be viewed in the context of the activity level on the NCS, which shows a relatively stable rise in the number of working hours in the period from 2000. Working hours on production facilities have been increasing slightly, whereas working hours on mobile facilities have varied somewhat, but with an increase since 2003. Fundamentally, there is a constant need for transport per

working hour, which implies an increase in both flight hours and person flight hours. This is offset by better utilisation of the helicopters, and the new helicopters' ability to take off with the maximum number of passengers under virtually all weather conditions.

On several facilities, shuttling is part of everyday life. Most shuttling takes place on the Ekofisk field. To a certain degree, shuttling now takes place using larger helicopters than before. The new helicopter types can also be utilised better with regard to the cabin factor. To a certain degree, this may explain the fall in flight hours at the same time as the number of person flight hours is increasing. The increase in the volume of person flight hours in 2012 (20.9%) can be viewed in the context of carrying out a major maintenance programme which necessitated more shuttling between the facilities.

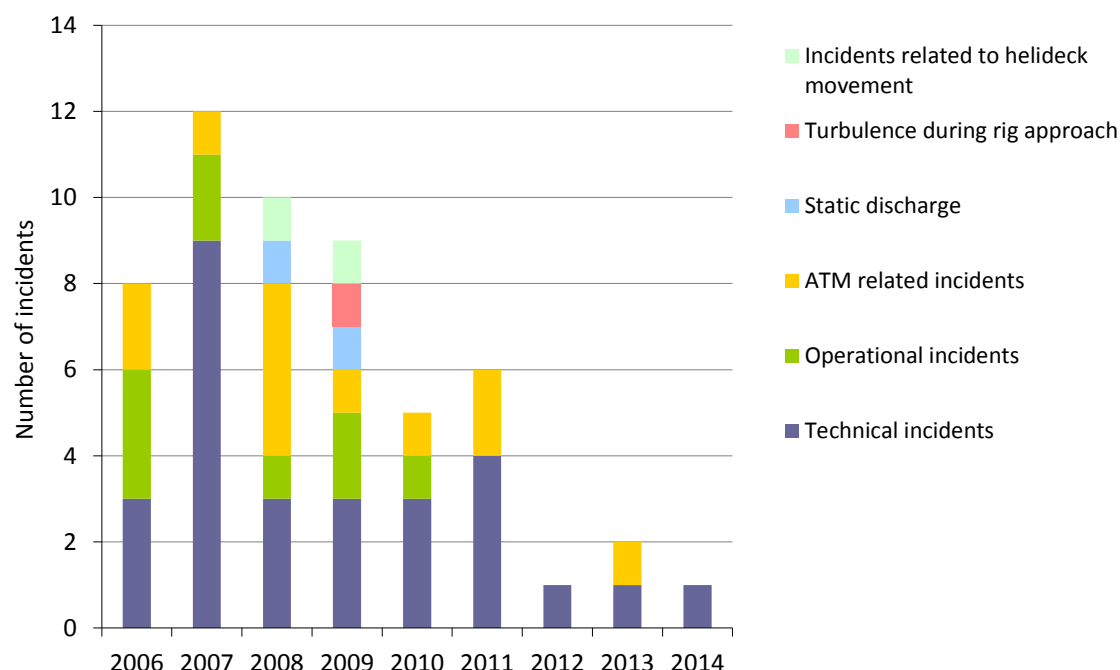
## **5.2 Incident indicators**

### **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. As previously, incidents during the parked phase onshore are not included.



**Figure 4 Incident indicator 1, incidents with little or medium remaining safety margin, 2006–2014**

The incident included in incident indicator 1 for 2014 relates to a torch left in proximity of a gearbox. The incident was assessed conservatively since the torch was located after flight without their being visible damage to the gearbox. It could however have caused major damage if it had moved and come into contact with the gearbox.

### 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 2008-2014 are presented in Figure 5–Figure 7. There was a strong reduction for helideck factors in 2010 compared with 2009. The number of incidents in the indicator has varied around this level in recent years, but with a slightly increasing tendency. In 2014, helideck incidents comprised around 14% of the total number of incidents with a safety impact. In 2014, as previously, the majority of incidents relate to floating facilities. There may appear to be a clear improvement in follow-up of procedures and routines on fixed facilities, which most likely reflects the industry's focus on such factors. The largest contributor to this indicator in 2014 is procedural breaches, as was the case in the four

preceding years. The indicator for ATM incidents shows a slight increase for the last two years following a sharp reduction from 2011 to 2012. This is assumed in part to be related to ongoing projects to increase ATM availability on the NCS. The incident indicator for bird strikes shows an increase in incidents recorded with a safety impact.

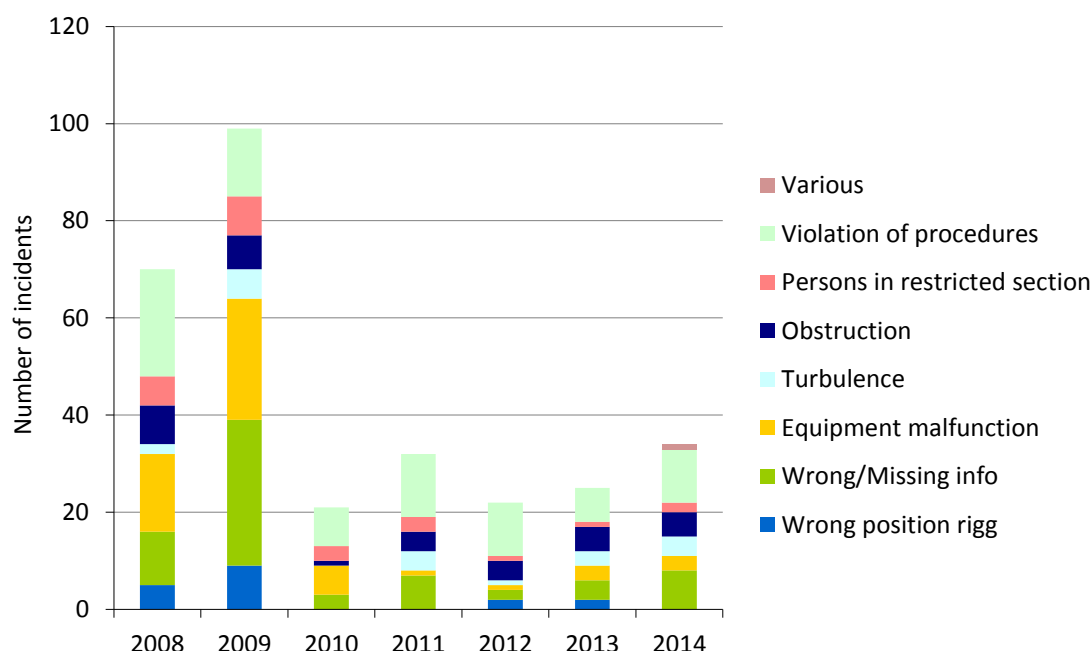
The absolute largest individual contributor to incidents with a safety impact is technical factors. This cause is not reflected in a separate indicator, but in 2014 accounts for nearly 60% of the total number of reported incidents with a safety impact.

Based on these causal indicators, the main report (PSA, 2015a) has indicated areas and aspects where improvements should be prioritised. The following new improvement proposals have been identified:

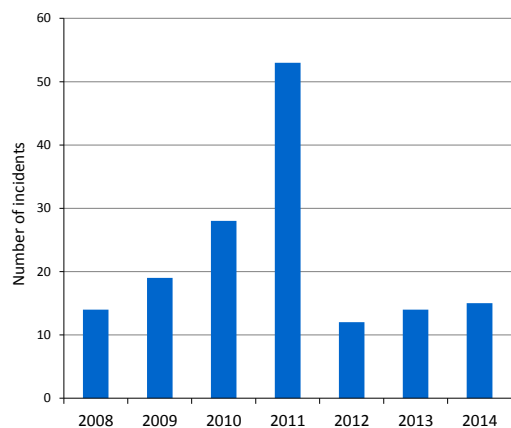
- 11. It is believed that a new update to the Helideck manual may be useful with a subsequent campaign for enforcing compliance. It is considered to be very important for all the helicopter operators on the NCS to be involved in this work.

In recent years, a number of incidents have been recorded where operational procedures were omitted/forgotten. This is something that the sector is concerned about and is working actively on. New technology with more sensors and safety barriers, as well as longer flights, may contribute to an increased risk relating to what the sector terms "pilot complacency". This term, also used untranslated in Norwegian, describes situations where pilots overlook, forget, are not fully focused or vigilant, and so forth. The causes of this may include: tiredness/fatigue, repetitive tasks or increased automation.

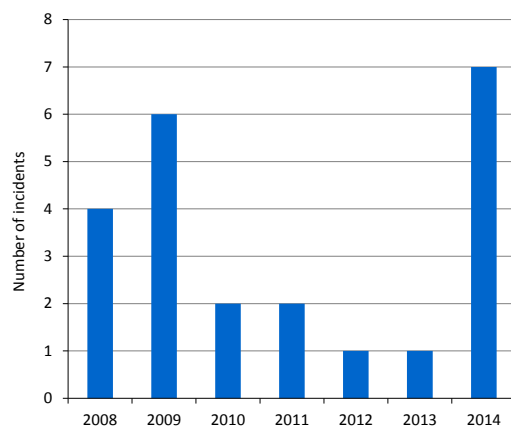
- 12. The helicopter operators and the Cooperation Forum for Helicopter Safety are recommended to continue work focused on complacency.



**Figure 5 Helideck factors, 2008–2014**



**Figure 6** *ATM aspects, 2008–2014*



**Figure 7** *Bird strikes, 2008–2014*

## 6. Status and trends – indicators for major accidents on facilities

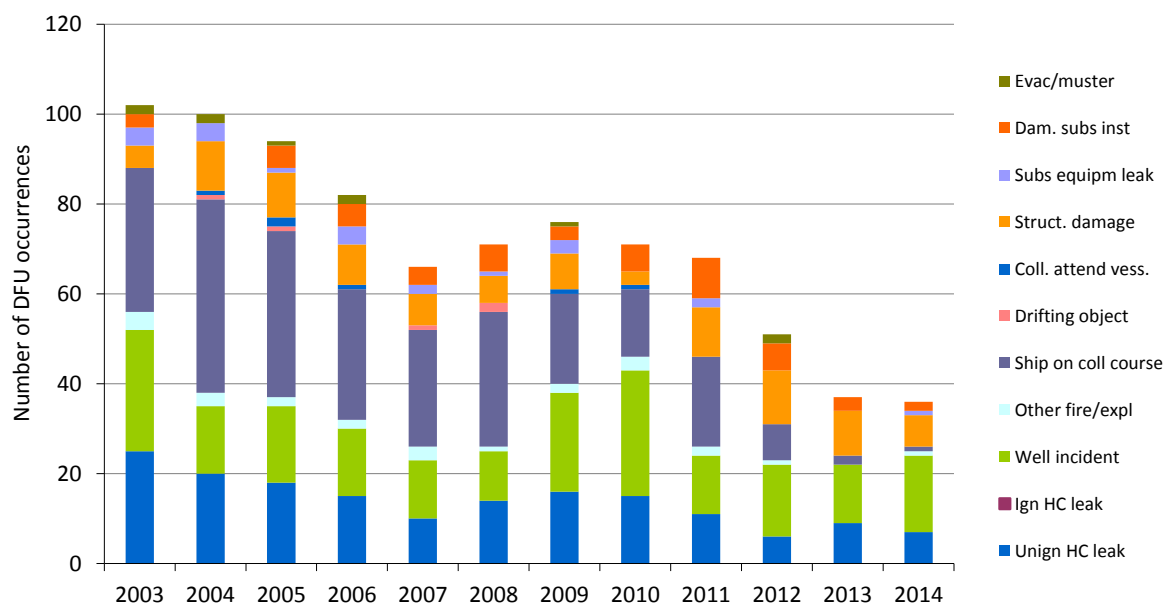
The indicators for major accident risk from previous years have been continued, with a primary emphasis on indicators for incidents and near-misses with the potential for causing a major accident. Indicators for major accident risk involving helicopters are discussed in Chapter 5, and barriers against 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. None of the DFUs that indicate major accident risk on facilities have resulted in fatalities 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 12 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 2003-2014. It is important to emphasise that these DFUs contribute very differently to risk. The clearly rising trend during the period 1996-2000 has been discussed in previous years' reports and has therefore been 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 2014, the number of incidents is at its lowest ever.

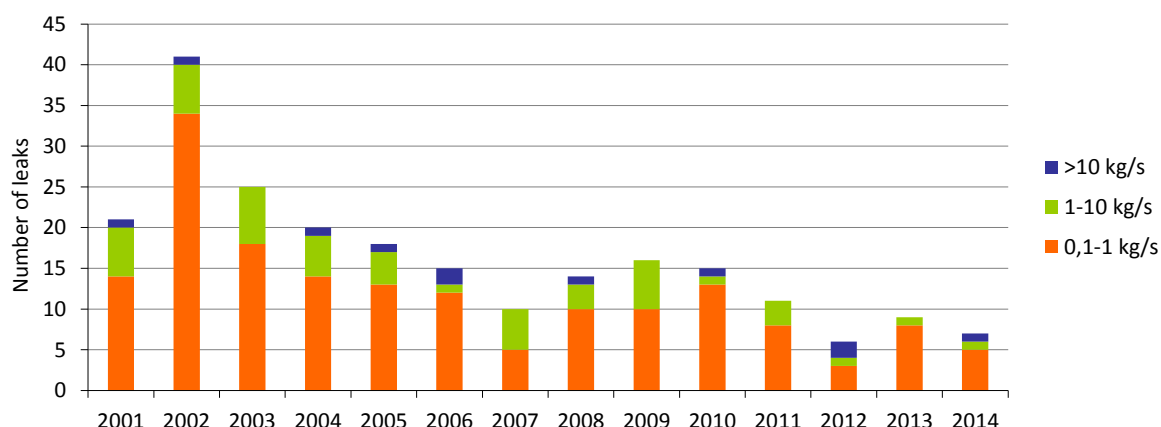


**Figure 8** Reported DFUs (1-11) by categories

### 6.2 Risk indicators for major accidents

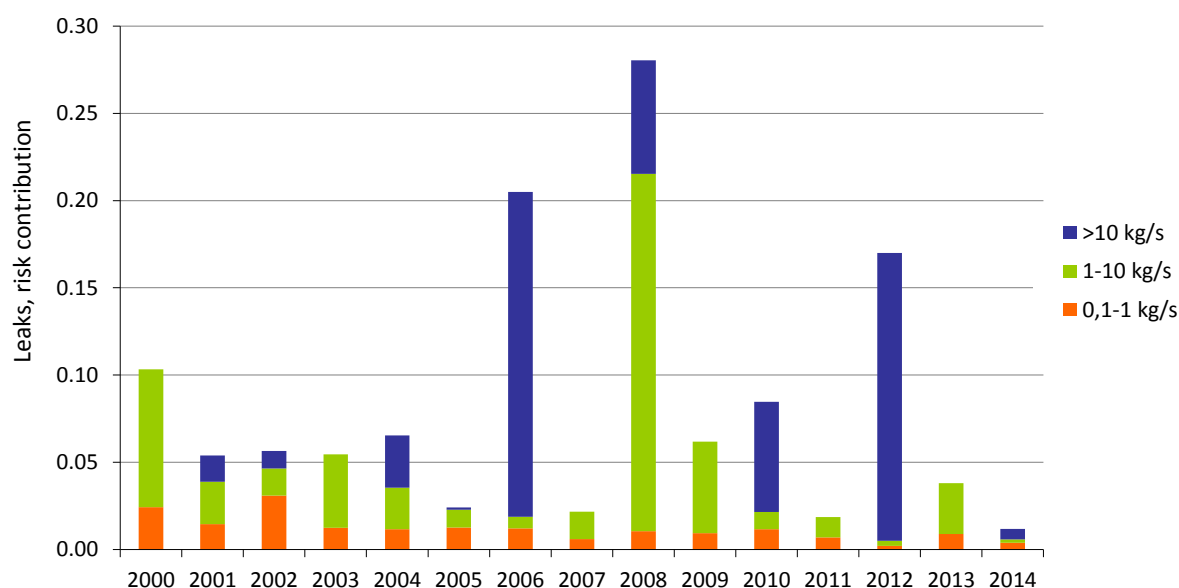
#### 6.2.1 Hydrocarbon leak in the process area

Figure 9 shows the number of hydrocarbon leaks greater than 0.1 kg/s in the period 2000-2014. 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 2014, one leak was recorded in the category >10 kg/s, one leak in the category 1-10 kg/s, and five in the category 0.1-1 kg/s. This is the second-lowest number recorded in the period. All the hydrocarbon leaks  $\geq 0.1$  kg/s in 2014 were associated with one operator.



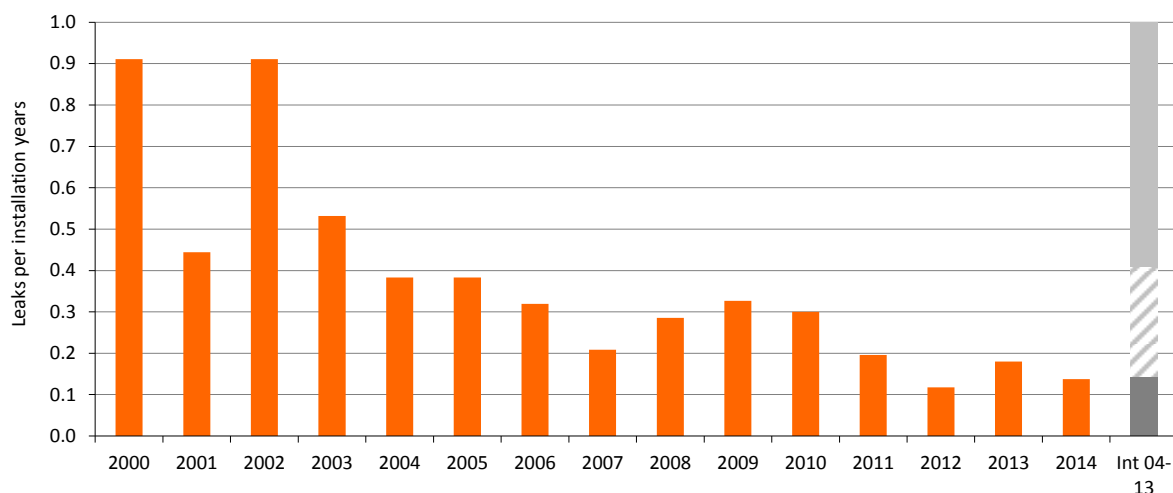
**Figure 9** Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2014

Figure 10 shows the number of leaks when these are weighted according to the risk contribution they are assessed as making. 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 leak in 2014 in the category >10 kg/s had a low risk potential due to the low proportion of gas. Since the rest of the leaks in 2014 had lower leakage rates, the overall contribution is relatively low. It is especially so compared with 2012, when two large leaks made the risk contribution the third-highest recorded in the period.



**Figure 10** Number of hydrocarbon leaks exceeding 0.1 kg/s, 2000-2014, weighted according to risk potential

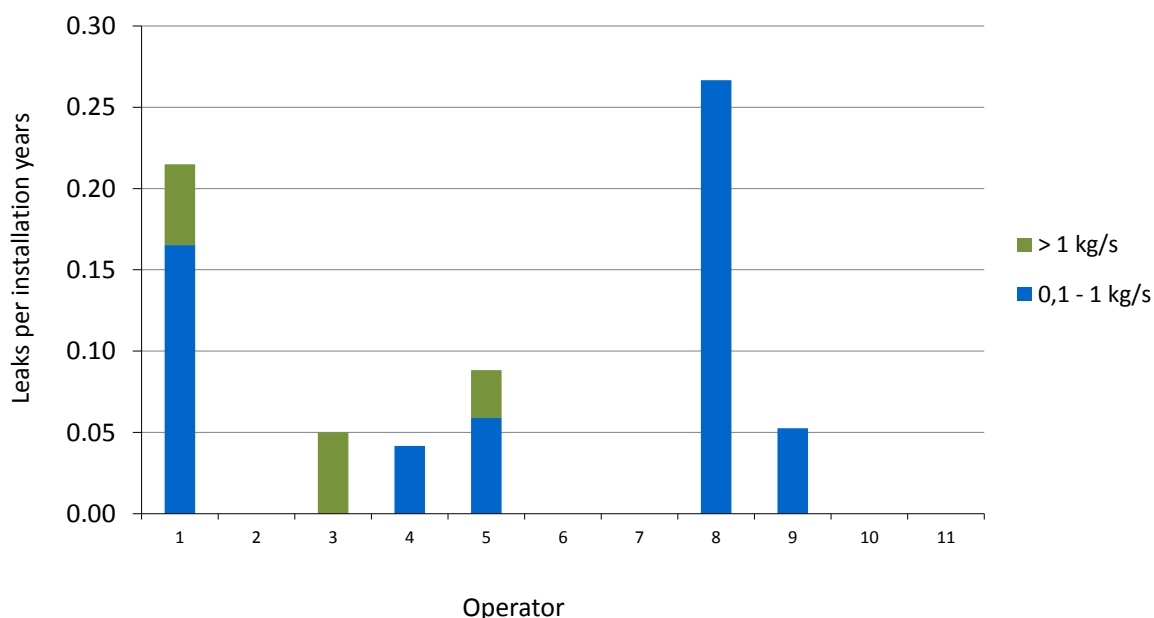
Figure 11 shows the trend in leaks exceeding 0.1 kg/s, normalised against facility years, for all manned production facilities. The figure illustrates the technique used throughout to assess the statistical significance (validity) of trends. Figure 11 shows that the reduction in the number of leaks per facility year in 2014 is just below the prediction interval and is statistically significant relative to the average for the period 2004-2013. This is indicated by the height of the column for 2014 being immediately below the middle grey shaded area in the column on the far right of the figure ("Int 04-13", 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.

When the average leak frequency is charted for each individual facility, the three facilities with the highest average frequency during the period 2010-2014 – all with the same operating company – together account for 21 % of the number of leaks on the NCS during this period.



**Figure 12** *Average leak frequency per facility year, 2010-2014*

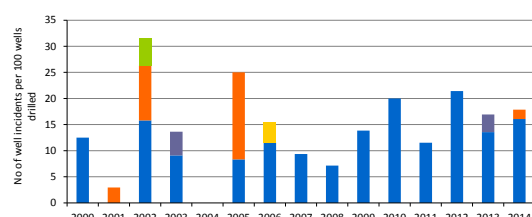
### 6.2.2 Loss of well control, blowout potential, well integrity

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.

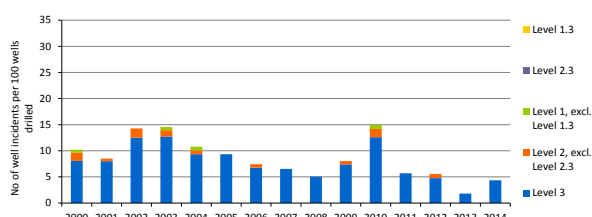


For exploration drilling, there were major variations throughout the period. There was a considerable reduction during the period 2005-2008 and significant variation during 2009-2014. The level during this period appears to represent a break with the positive trend during 2005-2008. Incidents during 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 has been a declining trend for production drilling. The level in 2014 is not statistically significant compared with the average of the preceding period. In 2014, all the well control incidents, except one, are in risk category level 3, i.e. incidents with minor potential. One was in risk category level 2.

#### EXPLORATION DRILLING

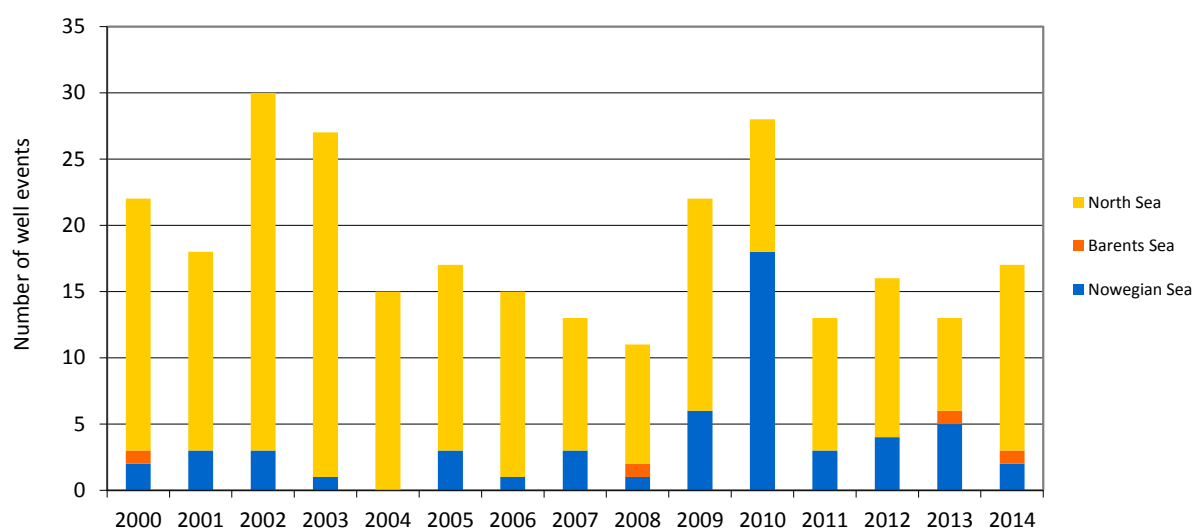


#### PRODUCTION DRILLING



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

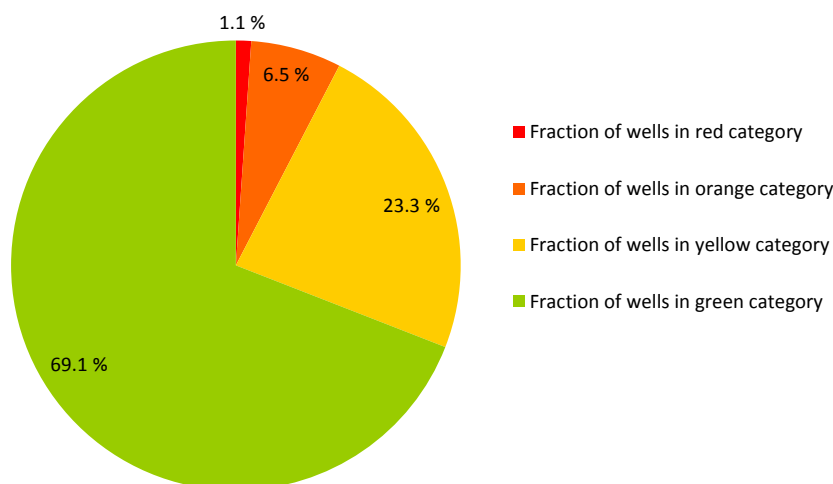
Figure 14 shows an overview of all well control incidents (for exploration and production wells) in relation to the areas on the NCS where the well control incidents have occurred. The area divisions correspond to the same divisions used on the Norwegian Petroleum Directorate's shelf map.



**Figure 14 Distribution of well control incidents by areas, 2000-2014**

The Well Integrity Forum (WIF) established a pilot project for performance indicators (KPIs) for well integrity in 2007. A total of 14 operating companies have reviewed all their "active" wells on the NCS, a total of 1918 wells in 2014, 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.

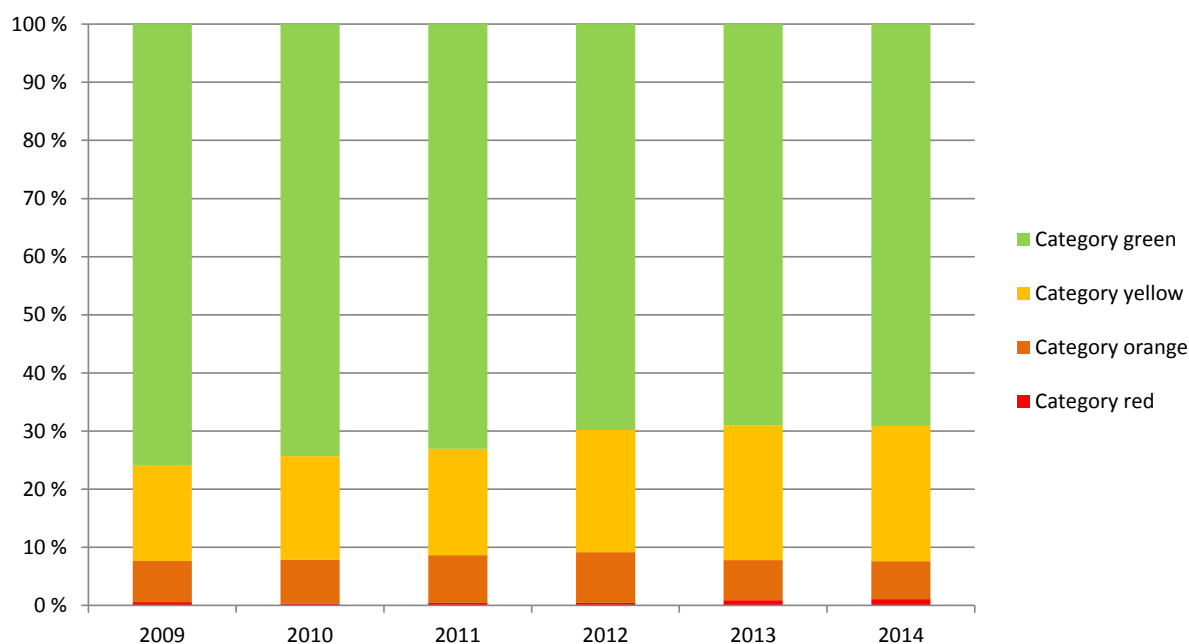


**Figure 15 Well categories - red, orange, yellow and green, 2014**

The mapping shows an overview of well categories distributed according to the percentage of the total sample of 1918 wells.

The results show that 7.6% of the wells have reduced quality compared with the requirement for two barriers (red + orange category). 23.3% 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. 69.1%, are in the green category. These are deemed to be in full compliance with the requirement for two barriers.

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



**Figure 16 Development in well categories, 2009-2014**

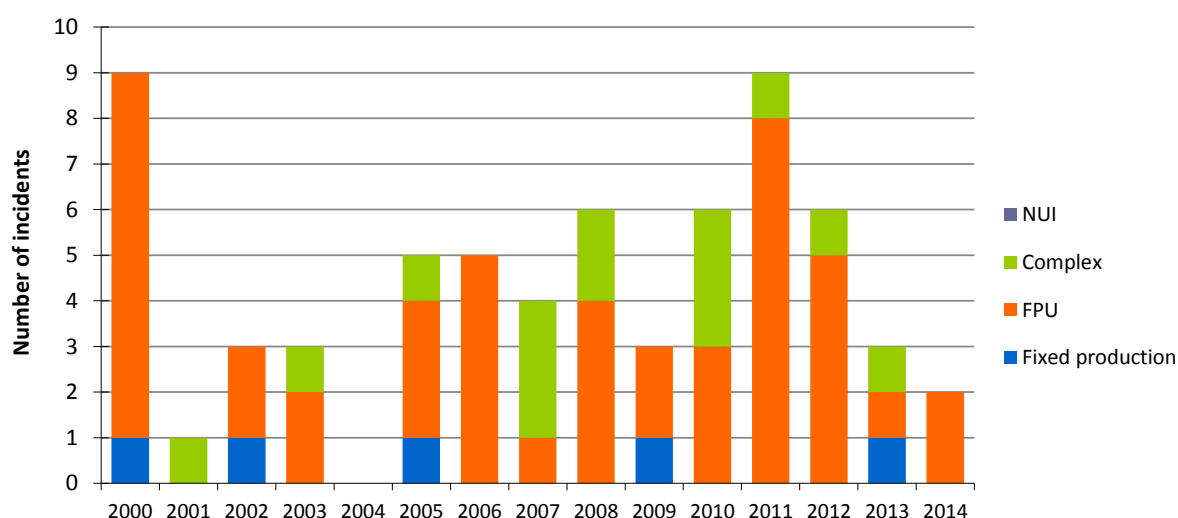
### 6.2.3 Leak/damage to risers, pipelines and subsea facilities

No leaks from risers to manned facilities were reported in 2014. Nor were any leaks from pipelines reported in 2014. During inspection of a subsea facility, excavations were discovered around a well template. Following closer investigation, it was judged that the

most probable causes of the excavation were outflow, shallow gas pockets, the connection between the formation strata and the well, or a combination of these factors. The incident includes both damage to a subsea facility and a leak, but will only be reported here as a leak. The leak is categorised as serious.

In 2014, two incidents of serious damage to risers and pipelines within the safety zone were reported. As in the previous year, all the serious incidents in 2014 concerned flexible risers.

Serious damage 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 2000-2014.



**Figure 17 Number of incidents involving serious damage to risers & pipelines within the safety zone, 2000-2014**

#### 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 11 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.

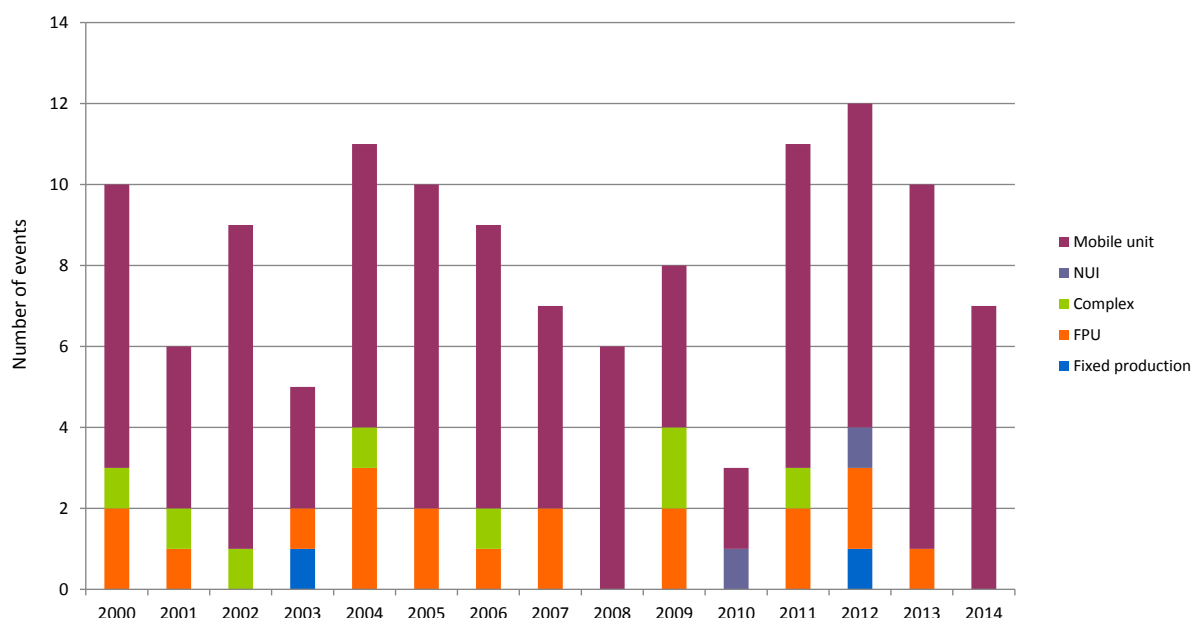
There were two collision incidents in 2014; Blue Protector collided with Oseberg Øst, when the vessel approached for cargo handling; Skandi Gamma was lying on the starboard side of Stena Don when it suffered a black out, resulting in loss of engine power. This caused the vessel to reportedly approach Stena Don and allide with the facility in two places.

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 2014, 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.



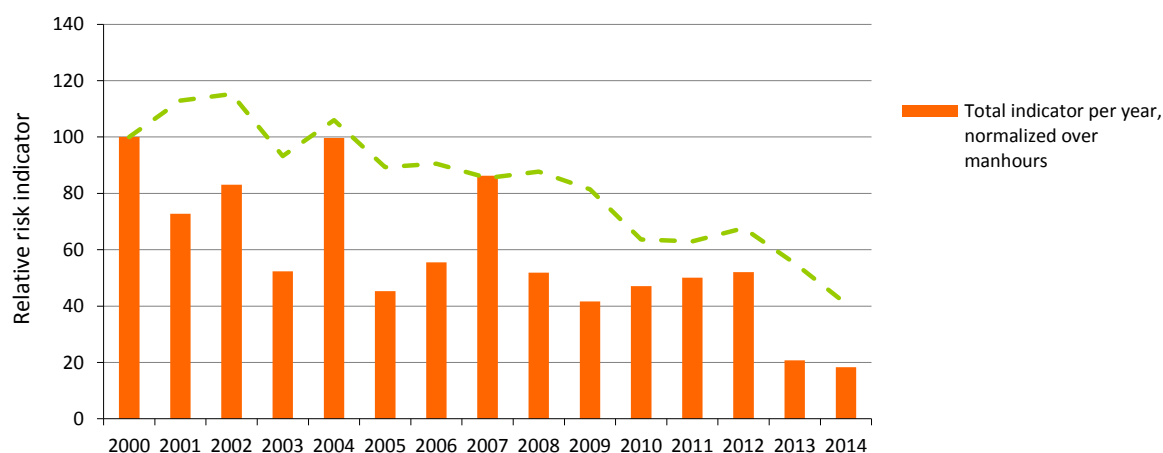
**Figure 18** Number of serious incidents and incidents involving damage to structures and maritime systems which conform to the criteria for DFU8

### 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 5. 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.

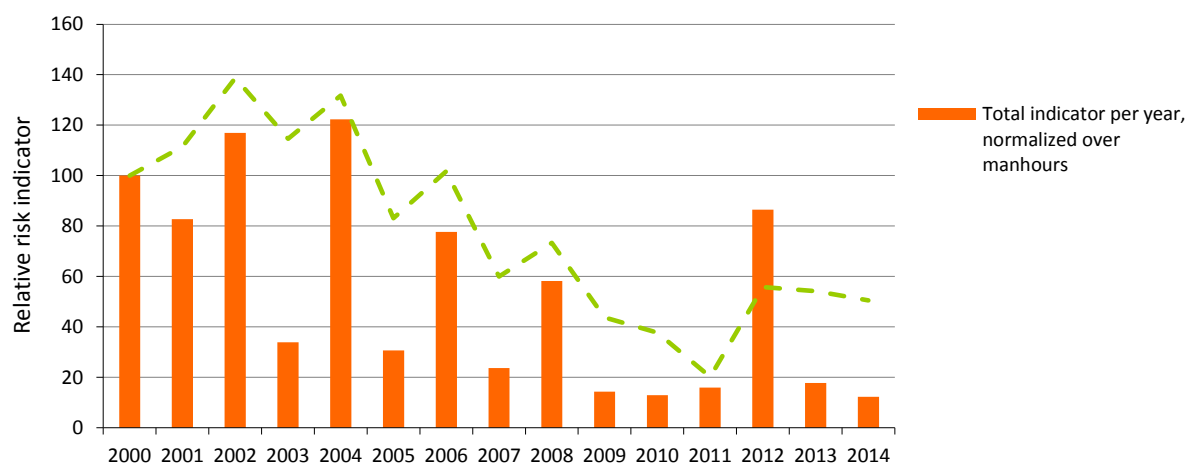
The total indicator weights the contributions from the observations of the individual DFUs according to the potential for loss of life (see the pilot project report), and will therefore vary considerably, based on the observations of the individual DFUs. Figure 19 shows the indicator for production facilities 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 the last two years, the total indicator has fallen further. 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 2014, this resulted in the lowest recorded relative risk indicator for the period 2000-2014.



**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.



**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.

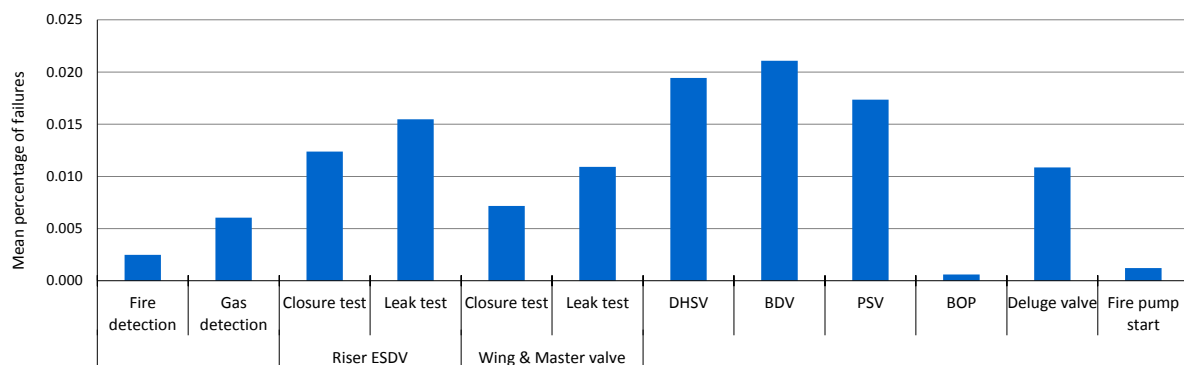
### 7.1 Barriers in the production and process facilities

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 has been collected. The test data is based on reports from all production operators on the NCS.

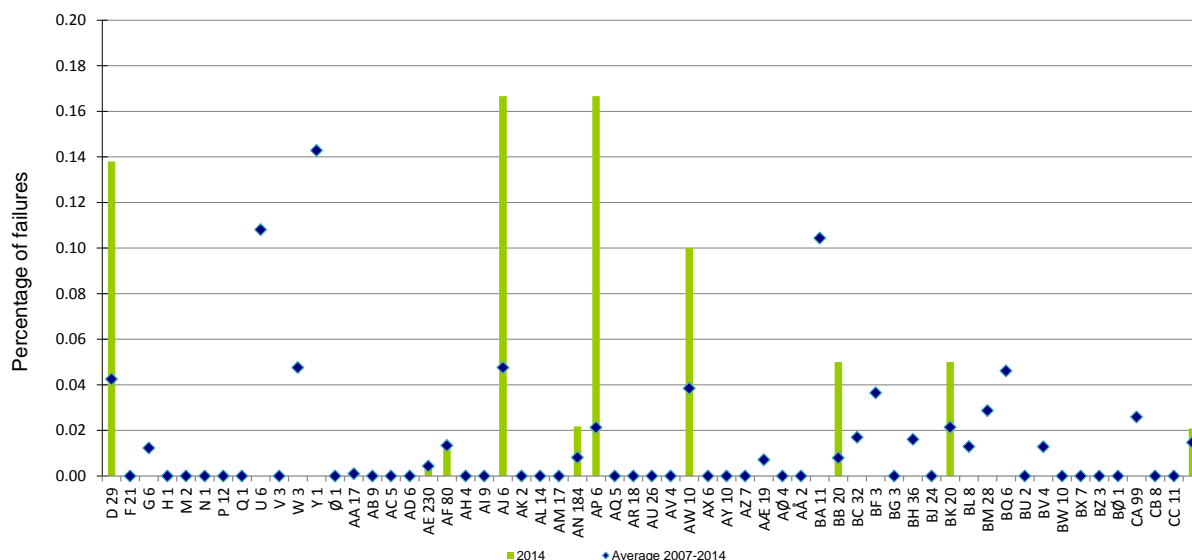


**Figure 21 Mean percentage of failures for selected barrier elements, 2014**

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 shows 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 such a 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 2014, the average percentage of failures during the period 2007-2014, as well as the total number of tests carried out in 2014 (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 2014.

The industry standard for the ESDV closure test is 0.01, and the figure above shows that nine facilities exceed the industry standard for the percentage of failures in 2014 and 20 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 11 years for most barriers. Overall, many facilities performed below or far below the industry standard for several of the barrier elements, both in 2014 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 2014 and for the period 2002-2014. 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 2014 and the mean percentage of failures for 2002-2014 for riser ESDVs, blowdown valves (BDVs) and deluge valves<sup>2</sup> are above the industry standard. The same is true of the mean percentage of failures for 2002-2014 for DHSVs which were also somewhat above the industry standard in 2014.

<sup>2</sup> The industry standard of 0.005 for BDVs is relatively strict, but even with a less strict industry standard, for example at 0.02 as for DHSV and Christmas trees, a considerable number of facilities would still be far above the industry standard.

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

Barrier elements	Number of facilities where tests were performed in 2014	Average, number of tests, for facilities where tests were performed in 2014	Number of facilities with a percentage of failures in 2014 (and avg 02-14) higher than industry standard	Mean percentage failures in 2014	Mean percentage failures 2002-2014	Industry standard for availability (Statoil)
Fire detection	70	803	3 (7)	0.002	0.004	0.01
Gas detection	69	391	10 (15)	0.006	0.009	0.01
Shutdown:						
· Riser ESDV	59	29	9, 3 (20, 18)* <sup>3</sup>	<b>0.013</b>	<b>0.020</b>	0.01
· Wing and master (Christmas tree)	66	253	4, 10 (3, 5)* <sup>3</sup>	0.009	0.010	0.02
· DHSV	66	103	23 (23)	0.019	<b>0.020</b>	0.02
Blowdown valve (BDV)	60	64	28 (47)	<b>0.021</b>	<b>0.023</b>	0.005
Pressure safety valve (PSV)	69	141	13 (15)	0.017	0.025	0.04
Isolation using BOP	22	137		0.0006	0.019	* <sup>4</sup>
Active fire safety:						
· Deluge valve	65	32	10 (24)	<b>0.011</b>	<b>0.012</b>	0.01
· Start test	60	121	3 (10)	0.001	0.003	0.005

## 7.2 Barriers associated with maritime systems

In 2014, data was 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 floating production and mobile facilities. There are considerable variations in the number of tests per facility, from daily tests to twice per year. Approx. 7000 tests of watertight doors and approx. 140000 tests of ballast valves on mobile facilities were carried out in 2014.

The failure frequencies for these systems in 2014 were 0.005 for tests on watertight doors and 0.0021 for tests on ballast valves. The failure rate for ballast valve testing is at roughly the same level as for production facilities, while the failure rate for watertight door testing is a good deal higher for mobile facilities than for production facilities.

## 7.3 Indicators for maintenance management

In general, defective or deficient maintenance has often proved to be a contributory cause of major accidents. It is because of the potential for major accidents that safety work in general and the maintenance of safety-critical equipment in particular has been given so

<sup>3</sup> For riser ESDVs and wing and master valves, the *closure test* and *leak test* figures apply, respectively.

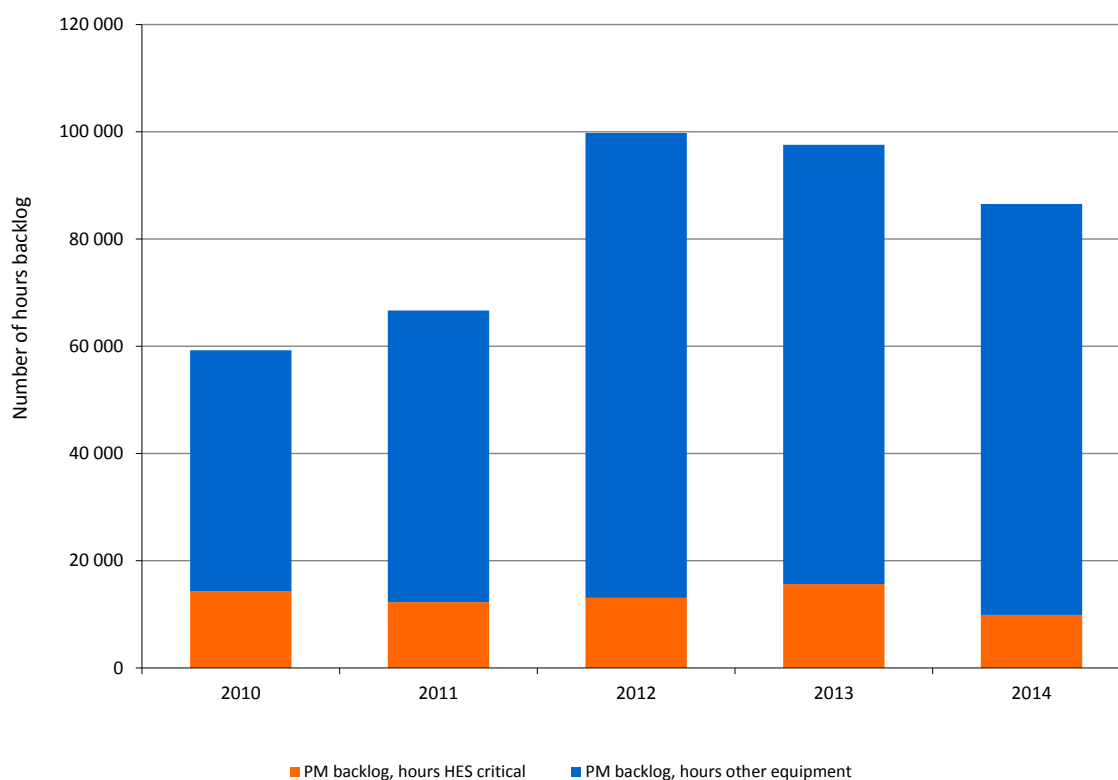
<sup>4</sup> There is no comparable requirement for this barrier, as an availability requirement is not considered to be appropriate. Statoil's internal guidelines recommend following up failures in this barrier using trend analysis.



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.

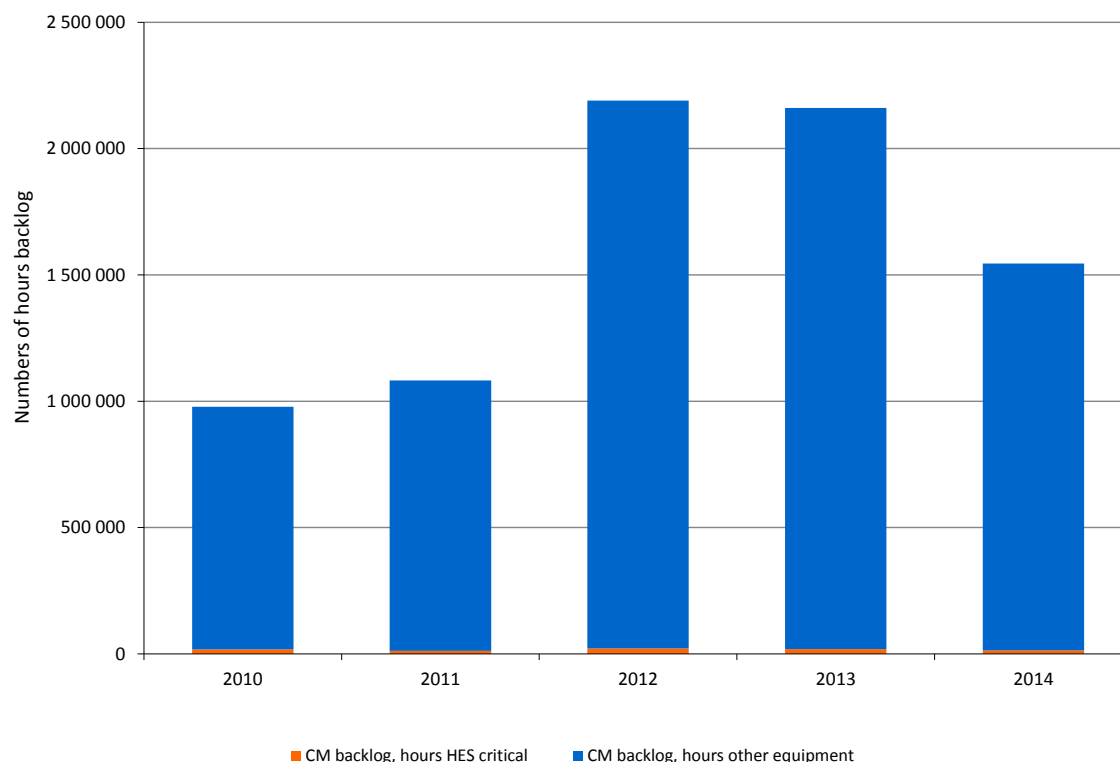
Since 2010, we have collected data from industry participants in order to monitor trends in selected indicators. This supplements information from our audits of participants' maintenance management. The objective is to reveal different aspects of the present situation and trends over time, to allow us to focus attention where it is needed. 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 collected data reflect the operators' own figures and systems for maintenance management. The main report shows many indicators; only two are shown here. Figure 23 and Figure 24 show the trends in, respectively, total backlog of preventive maintenance and total volume of outstanding corrective maintenance per year, totalled for all production facilities on the NCS.



**Figure 23** *Trend 2010-2014 of total backlog of PM per year for production facilities on the NCS*

Figure 23 shows that the total backlog of preventive maintenance for HSE-critical systems and HSE-critical equipment for the production facilities on the NCS fell in 2014 from the previous year. Backlogs in this HSE-critical preventive maintenance may entail poorer technical condition and hence increased risk of accident.

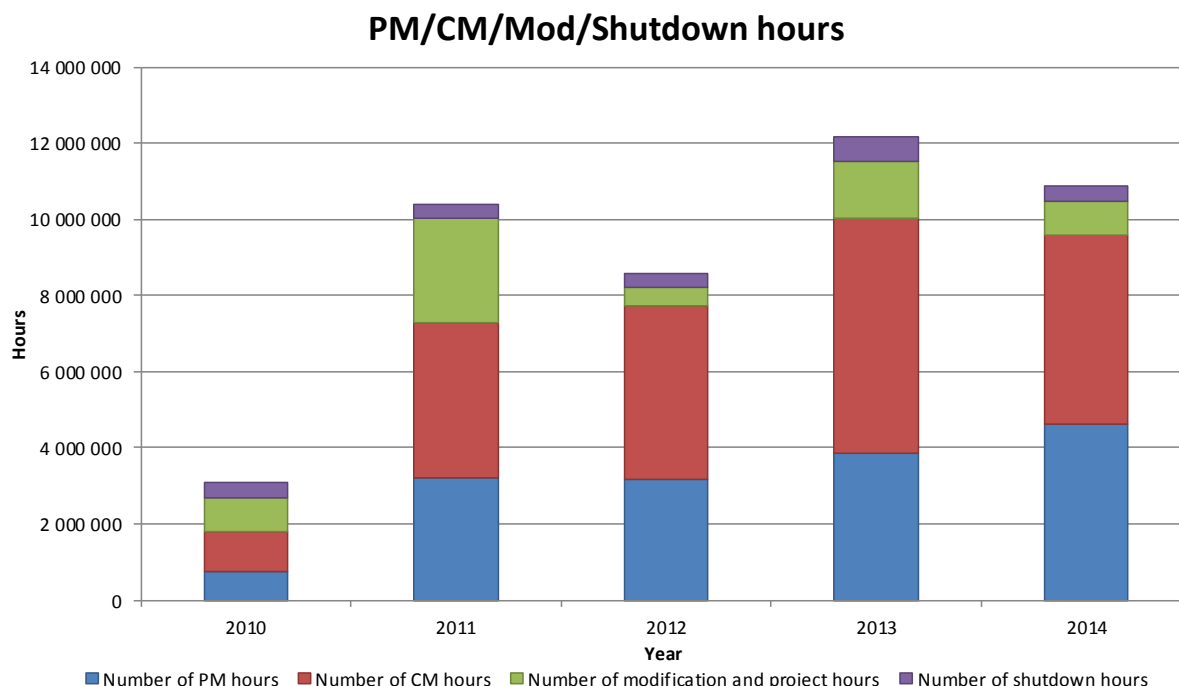


**Figure 24** *Trend 2010-2014 of total volume of outstanding CM per year for production facilities on the NCS*

Figure 24 shows a significant reduction in the total volume of outstanding corrective maintenance for 2014 compared with the two preceding years. The reduction was due primarily to two major participants on the NCS. On request (audit), one of the participants explained that clearing out and quality-assuring the CM portfolio contributed significantly to the reduction. The volume of outstanding corrective maintenance is however considerable.

On several occasions, we have emphasised the importance of participants assessing the significance of outstanding corrective maintenance, both as individual items and collectively. The assessment is crucial for determining the extent to which outstanding maintenance entails increased risk.

Figure 25 shows the number of hours of *performed maintenance, modifications and planned shutdowns* on all facilities for the period 2010-2014.



**Figure 25** *Trend in hours of work in the period 2010-2014. Note: Not all the participants supplied figures for 2010*

Figure 25 is particularly intended to provide an informative overview of the distribution of reported maintenance activities performed in 2014 (in hours). The figure shows an increase in preventive maintenance performed in 2014 compared with 2013. This indicates a relationship with the reduction in the preventive maintenance backlog shown in Figure 23.

The figure also shows a reduction in the amount of corrective maintenance performed in 2014 compared with 2013. Except for the reasoned reduction in the total amount of outstanding corrective maintenance mentioned above (see Figure 24), reported data does not explain the relationship between the fall in the total amount of outstanding corrective maintenance from 2013 to 2014 and the reduction in hours of CM performed in the same period, as shown in Figure 25. This will be examined further.

The reported data for backlogs in preventive maintenance and outstanding corrective maintenance for mobile facilities shows great variation. This is similar to what we have seen in recent years. The large variation in the reported data makes it difficult to carry out an assessment of the maintenance management for the mobile facilities on the NCS.

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

For 2014, the PSA registered 325 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 2013, 355 personal injuries were reported. There were no fatal accidents within the PSA's area of authority on the NCS in 2014. The last fatality was in 2009.

In addition, 50 injuries classified as off-work injuries and 37 first aid injuries were reported in 2014. For comparison, in 2013 there were 39 off-work injuries and 41 first aid injuries. First aid injuries and off-work injuries are not included in figures or tables.

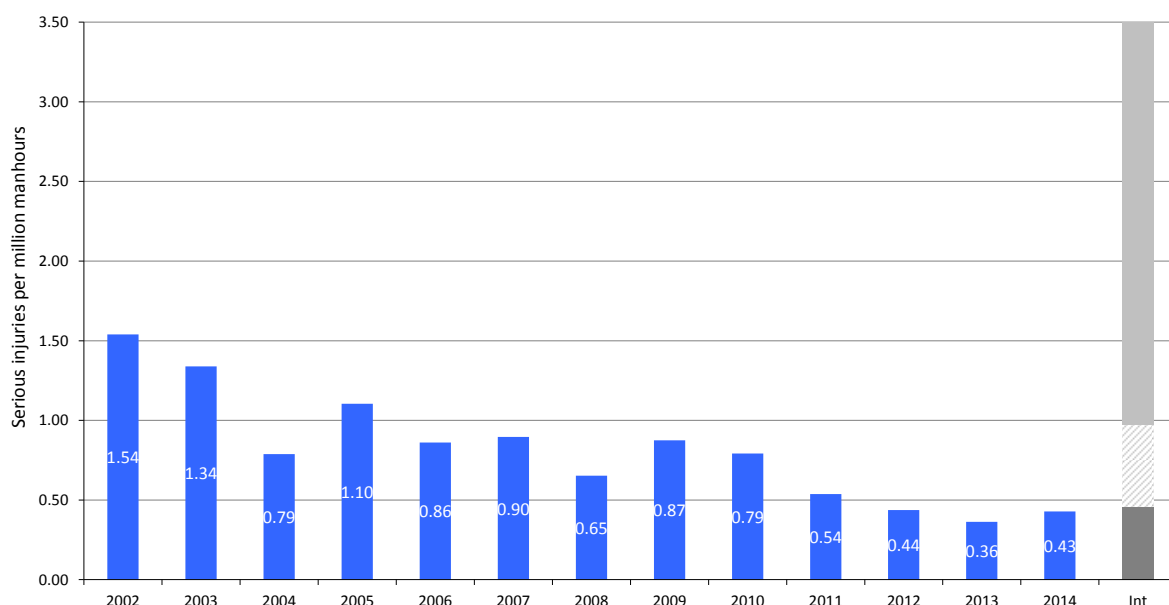
In recent years, we have seen a clear reduction in the number of injuries reported on NAV (Norwegian Labour and Welfare Administration) forms, and this trend continued in 2014. In 2014, as many as 37.5% of the injuries were not reported to the PSA on NAV forms. These injuries are therefore recorded on 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 2004 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.

As on production facilities, mobile facilities have also seen a positive long-term trend, and the rate has more than halved relative to the 2004 level. The injury rate fell from 11.7 in 2004 to 5.3 in 2014. From 2011 to 2013, the overall injury rate was essentially unchanged at around 7 injuries per million working hours. In 2014, the overall injury rate fell by 1.4 personal injuries per million working hours relative to the preceding year. The rate went from 6.7 in 2013 to 5.3 injuries per million working hours in 2014. This is the lowest recorded rate for the entire period. The activity level on mobile facilities fell by 1 million hours from 2013 to 2014.

### 8.1 Serious personal injuries, production facilities

Figure 26 shows the frequency of serious personal injuries on production facilities per million working hours. With the exception of the change from 2004 to 2005, there has been a very 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 2014 there was however a small upturn when the injury rate rose from 0.36 in 2013 to 0.43 in 2014. The 2014 level is nonetheless significantly lower than the average for the preceding decade. In 2014, the injury rate for serious personal injuries on production facilities is dominated by contractors' employees, since no injuries were recorded for operators' employees on production facilities. The converse was true in 2013. In that year, the serious personal injury rate for contractors' employees was lower (0.13) than the rate for operators' employees.

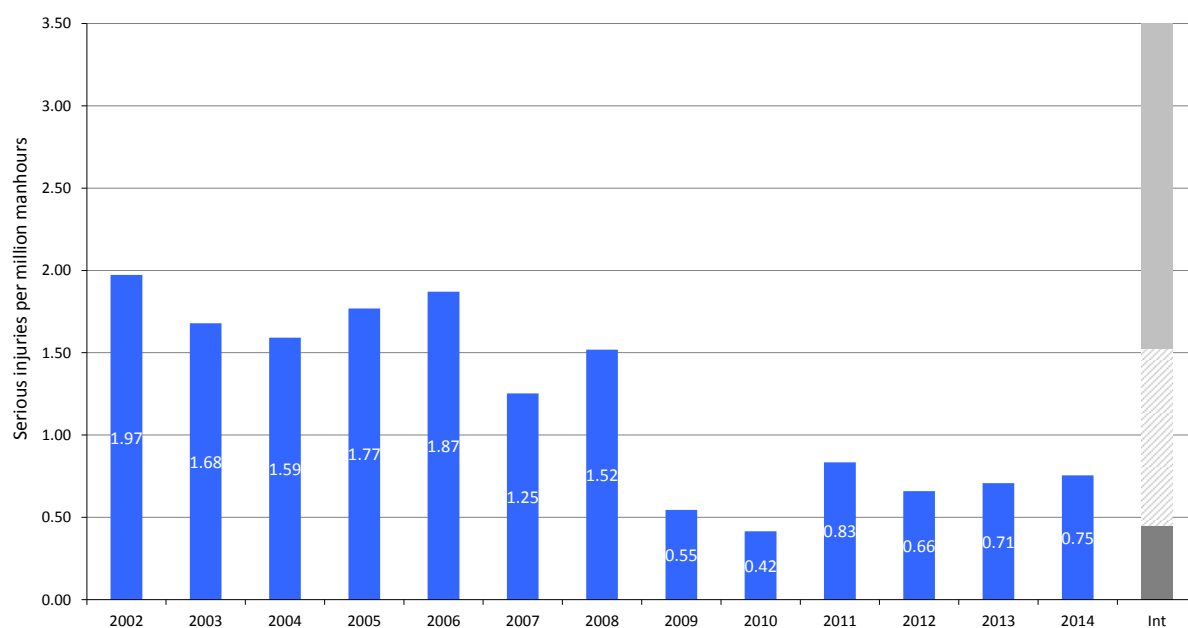


**Figure 26** *Serious personal injuries on production facilities relative to working hours*

## 8.2 Serious personal injuries, mobile facilities

Figure 27 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 noticeable regression before the trend flattens out in the next three years. In 2014, we have a marginal increase in the serious personal injury rate of 0.04 injuries per million working hours from 0.71 in 2013 to 0.75 in 2014. The injury rate is therefore within the expected values based on the preceding 10 years.

The number of hours reported for mobile facilities in 2014 fell by around 1 million, from 16.9 to 15.9 million. The number of serious personal injuries was 12 in both 2013 and 2014.



**Figure 27** *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 2008 up to the 2nd half of 2013 shows that there have been 0.6 injuries per million working hours on the Norwegian Continental Shelf and 0.7 on the UK Continental Shelf.

The average frequency for fatalities on the UK Continental Shelf is 0.6 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 two 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 has 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 four years, the indicator has been unchanged.

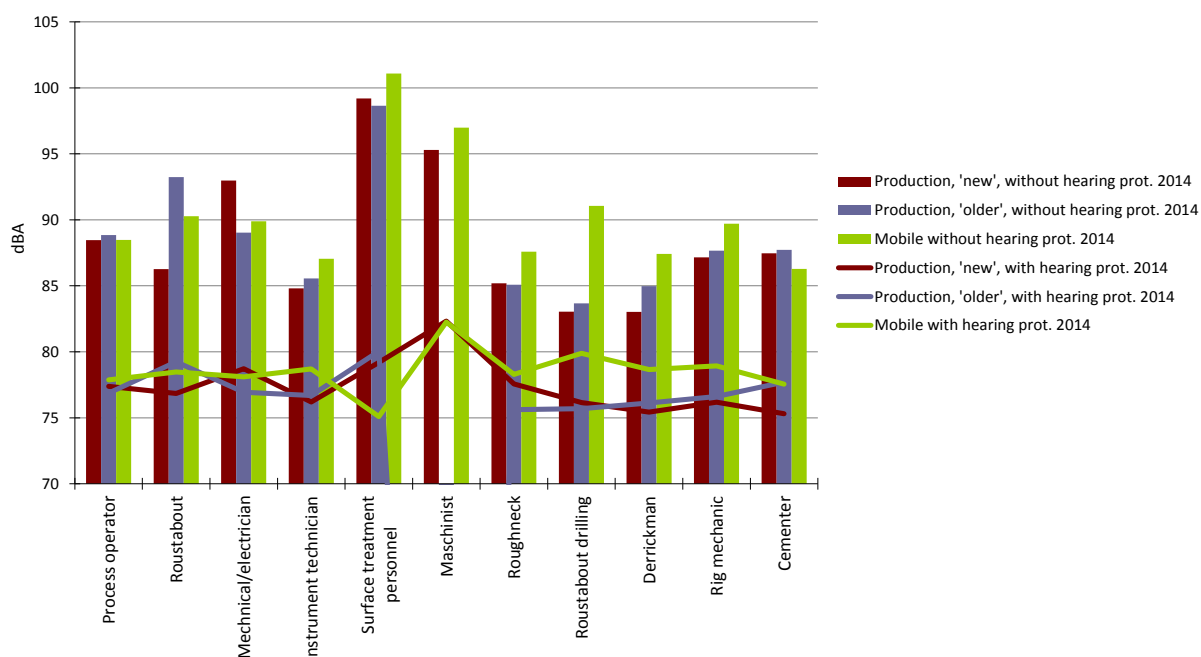
For ergonomics, data was recorded from all onshore facilities and most offshore facilities. Indicators for ergonomic factors have been reported annually in the period 2009-2014. Changes made over time to the data collection form, concerning both questions and more appropriate use of software, mean that consolidated data is most accurately comparable in the period 2012-2014. 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 2014, data has been reported from 83 facilities, 43 fixed production facilities and 40 mobile ones. Among the fixed production facilities, 18 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). One flotel has reported data.

The noise exposure indicator covers 11 predefined position categories. In all, data has been reported for 2,744 individuals, representing approx. 7,500 employees offshore. This is a fall from 2013, when 2,837 persons were involved.

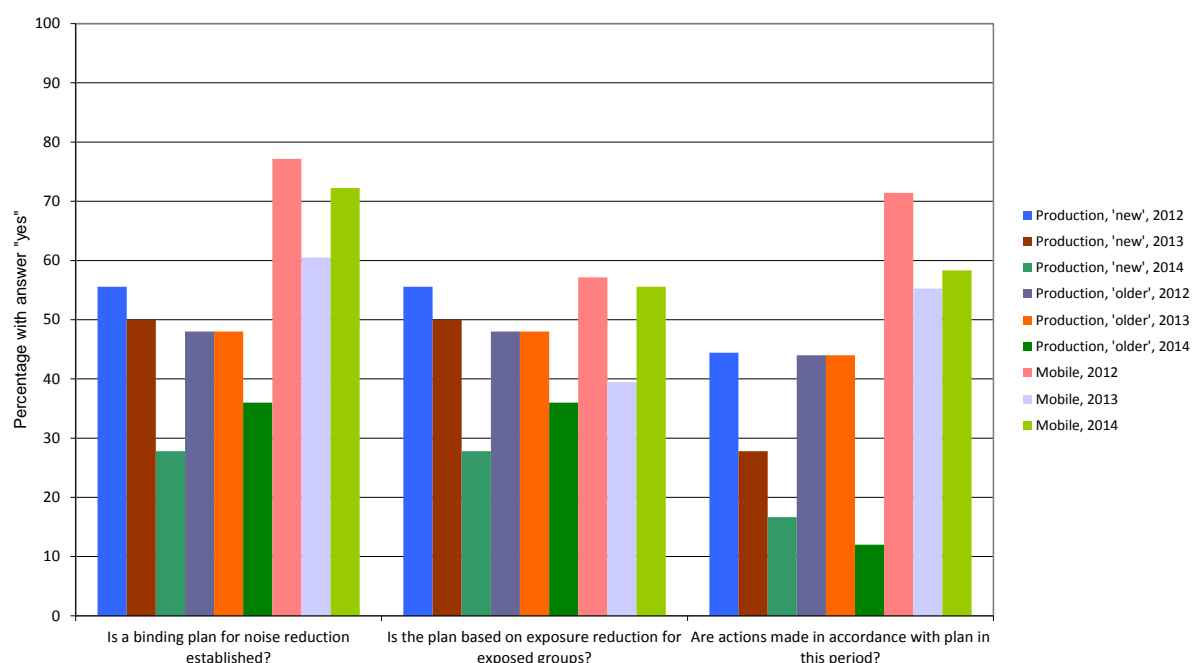


**Figure 28 Average noise exposure for position categories and facility type, 2014**

The results show an improvement in eight out of eleven position categories from 2013 to 2014. The position categories of surface treatment personnel and rig mechanics show a slight worsening. The average noise indicator value for all NCS activities has been relatively stable since 2010. In 2014, the indicator is 89.4. 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 80 facilities, eight have not introduced such schemes for any position categories. This applies especially to mobile facilities. As in previous years, there is still a potential for improvement within this area for mobile facilities. 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 29. The picture has developed in a negative direction, compared with 2013, for "new" and "older" mobile facilities. For mobile facilities, this is an improvement over 2013.



**Figure 29 Plans for risk-reducing measures**

For 2014, 239 (403 in 2013) new or worsened instances of reduced hearing and 67 (77 in 2013) 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 2014, the figures show a reduction in the number of new and worsened instances of reduced hearing. The same applies to the number of instances of tinnitus.

The Petroleum Safety Authority Norway has noted that, in recent years, both in the petroleum industry in general and in the companies themselves, there has been an increasing focus on and a greater willingness to implement risk-reducing measures.



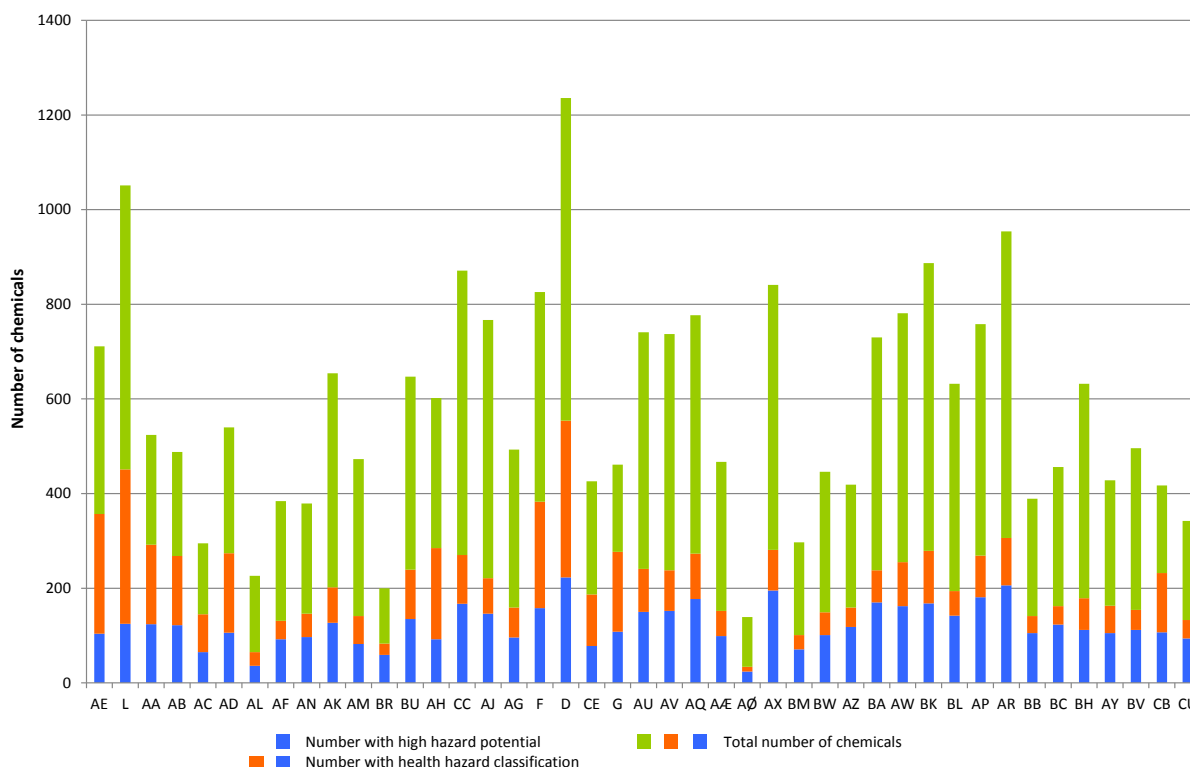
## 9.2 Chemical working environment

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.

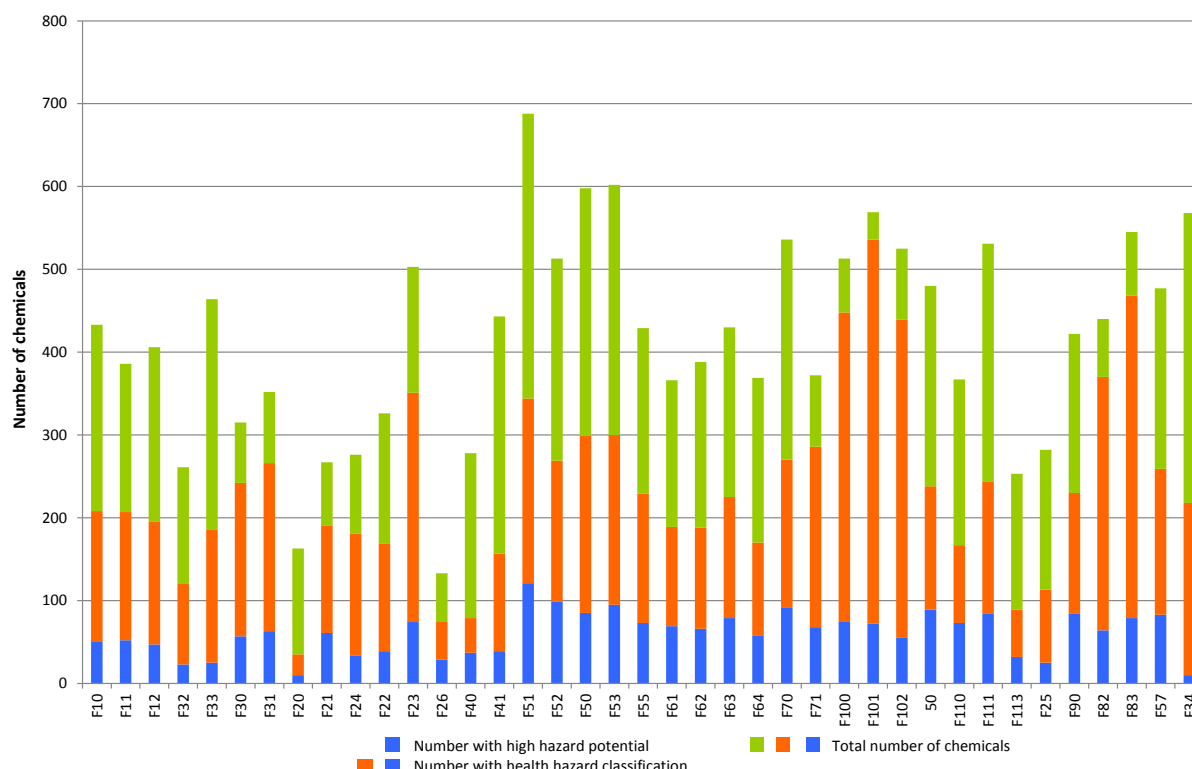
The indicator for the chemical spectrum's risk profile provides a picture of the number of chemicals in use per facility and how many of these have a high and defined risk potential. The indicator has limitations in that it does not take account of how the chemicals are actually used and the risk this 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 2014, data has been reported for a total of 82 facilities, 43 fixed production facilities and 39 mobile facilities.

The indicator for the chemical spectrum's risk profile shows that there is still considerable variation between facilities with regard to the number of chemicals in use (Figure 30 and Figure 31). To a certain degree, the variation reflects the type of facility and activities on the facility. Permanent installations generally have a higher number of chemicals in circulation than mobile facilities.



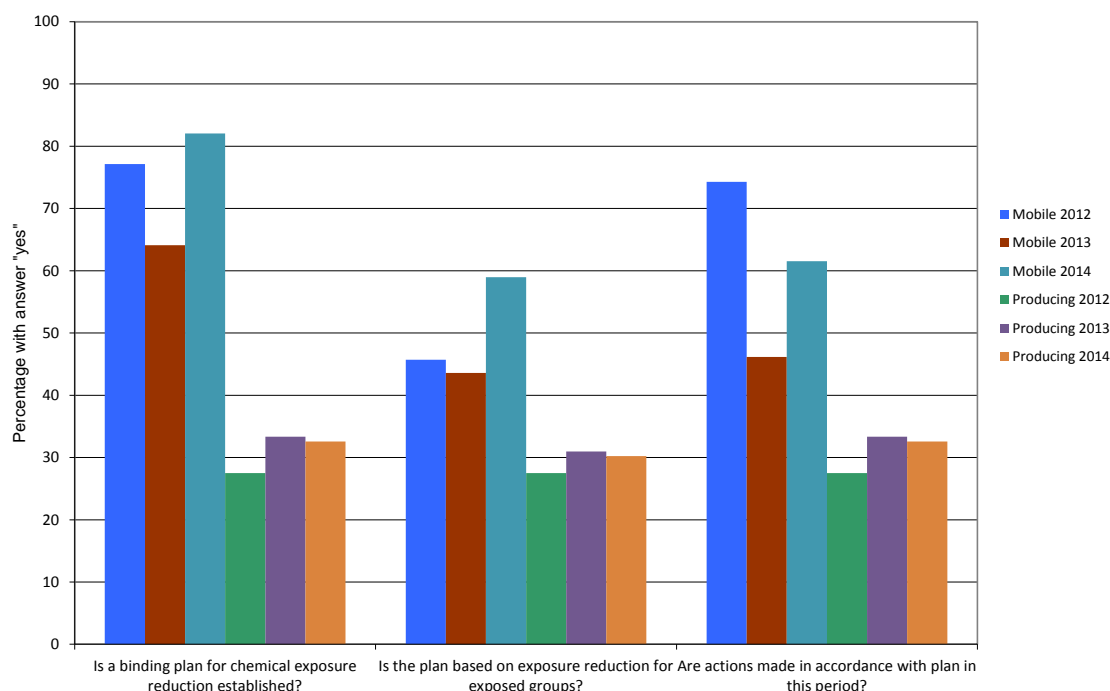
**Figure 30 Indicator for the chemical spectrum's risk profile – fixed production facilities**



**Figure 31 Indicator for the chemical spectrum's risk profile – mobile facilities**

Figure 32 gives a picture of the companies' management of chemical exposure risk. For fixed facilities, 33% report having established a binding plan for the reduction of chemical exposure on the facility. This is a slight decline relative to 2013. 30% report having a plan based on the reduction of exposure for vulnerable groups, and 30% report having implemented measures in line with plans for the reporting period.

For mobile facilities, just over 80% state having established a binding plan for the reduction of chemical exposure. This is an improvement on the preceding year. Around 60% report having a plan based on the reduction of exposure for vulnerable groups, and 62% report having implemented measures in line with plans for the reporting period.



**Figure 32 Management of risk of chemical exposure for mobile and production facilities**

In 2014, 49 new cases of occupational skin complaints mainly caused by chemical exposure were reported, compared with 43 cases in 2013.

### 9.3 Ergonomics

Indicators for ergonomic factors have been reported annually in the period 2009-2014. 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 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 2012-2014 are comparable. In 2013, the form was given a new layout and designed in Excel. In connection with this change, a working group was assembled consisting of participants from the industry with expertise in ergonomics. These provided input into the changes required to previous forms and feedback on the pilot version of the Excel reporting form. Based on input from this group, in 2014 further changes were made to the layout in order to simplify and improve reporting. Based on input from the working group and ergonomists onshore, minor specifications of individual work tasks were also performed with a view to achieving more consistent reporting.

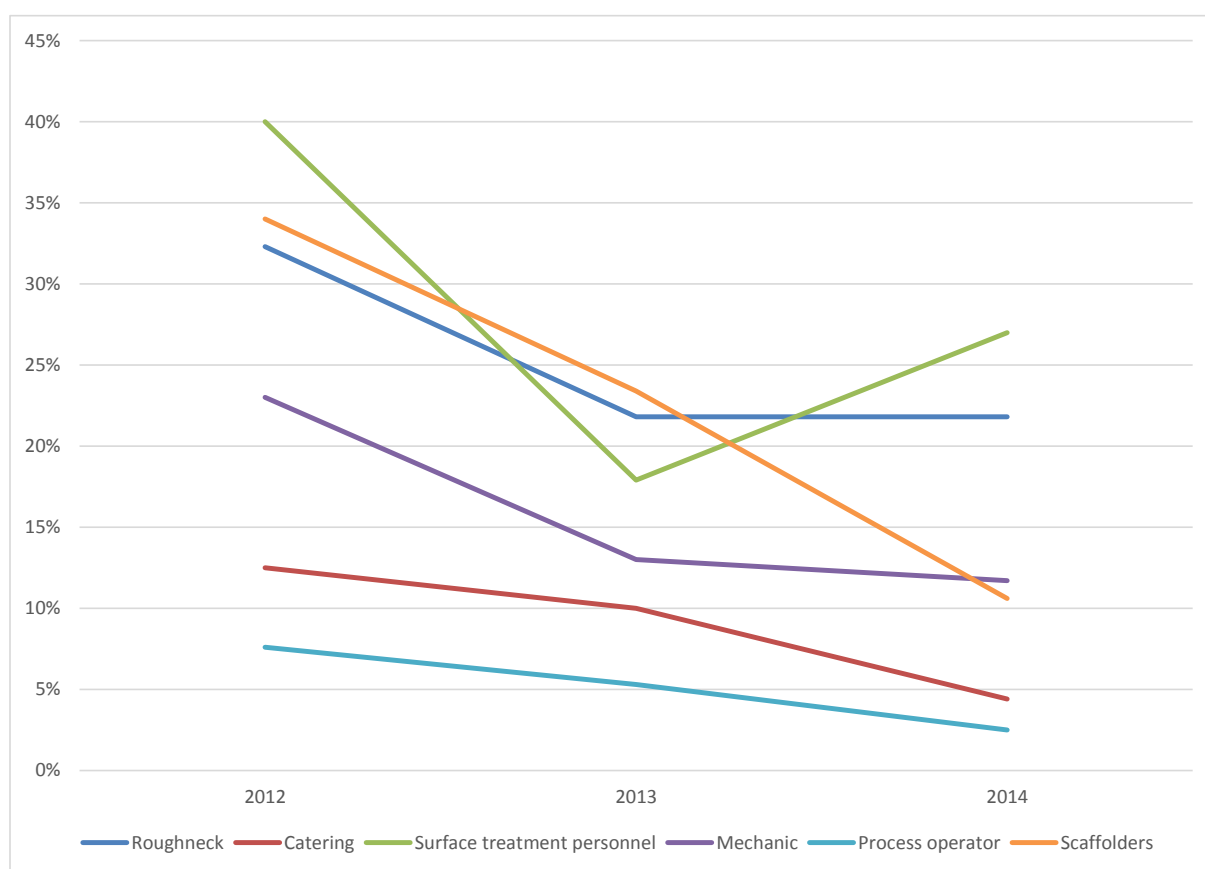
The indicators have been developed in cooperation with specialist environments in the companies and STAMI. The status overview "Work as a cause of musculoskeletal disorders" was prepared by STAMI in 2008 on assignment from the Norwegian Labour Inspection Authority and the Petroleum Safety Authority Norway, and has been used as a basis in developing the indicators. 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 50 production facilities and 37 mobile facilities. 1,251 work tasks were reported by the production facilities and 862 by the mobile facilities.

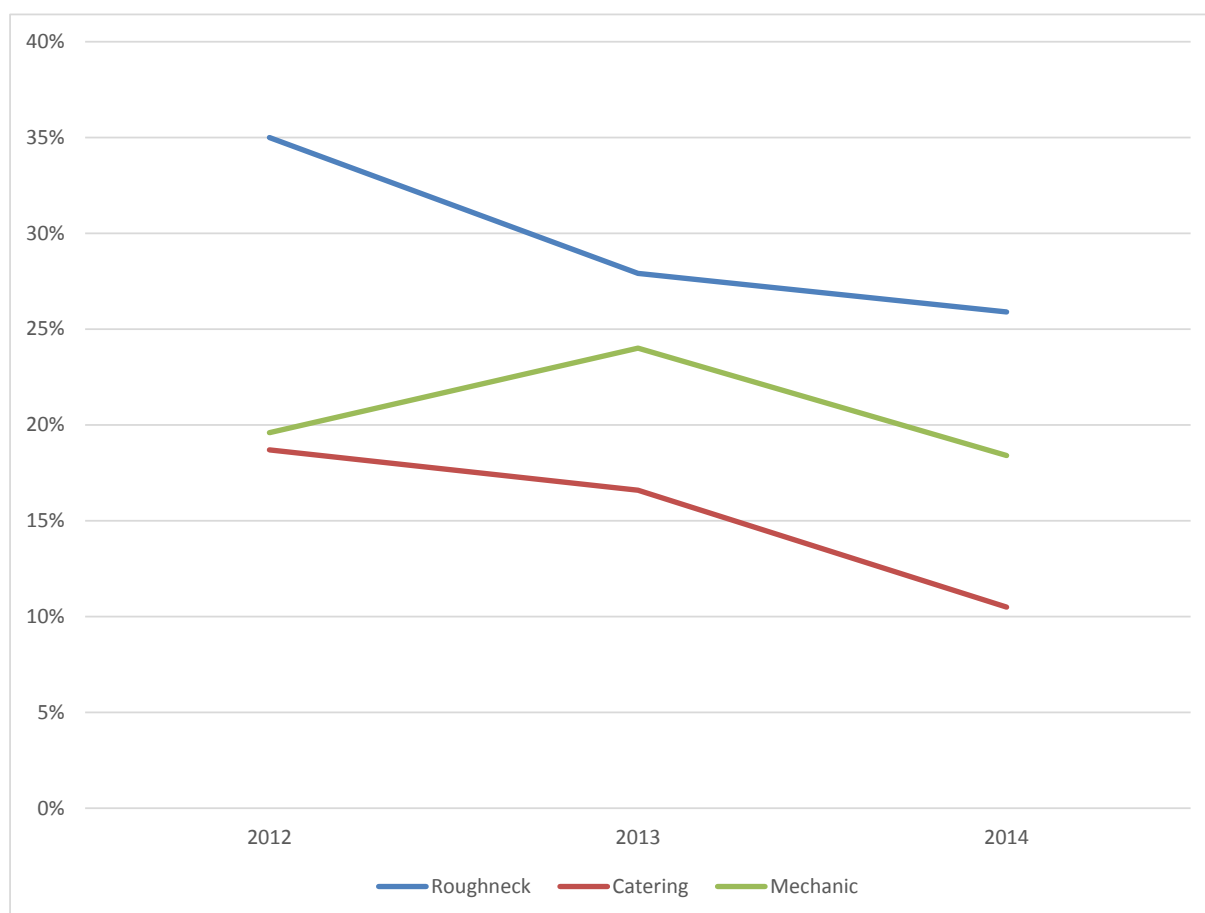
In the reporting form, working position, repetition, lifting/carrying and hand-held tools were classified as working environment factors. These factors were evaluated as red, yellow or green. In the *red* area, the probability of sustaining repetitive strain injuries is very high. A change in the working 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.

The quality of this year's reporting is better than previous years. This is due to the new template for reporting implemented in 2013, and the form's layout producing more consistent reporting. In a few instances, however, the old form was used. In these cases, the sender was contacted and requested to use this year's template for reporting. There were also cases where work tasks were copied from the old form and pasted into this year's form. These forms, however, were blocked at data entry since individual work tasks had been subject to minor changes in nomenclature. In these cases too, the sender was contacted and requested to use this year's template for reporting.



**Figure 33** Proportion of work tasks for the individual employee groups on production facilities which as a whole were given red assessments in the period 2012-2014.



**Figure 34** *Proportion of work tasks for the individual employee groups on mobile facilities which as a whole were given red assessments in the period 2012-2014.*

The results show that on production facilities and on mobile facilities, it is roughnecks and surface treatment personnel who have the highest risk scores. For mobile facilities, a fall in risk scores is reported for all employee groups. On newer production facilities, equivalent or lower risk scores are reported for all employee groups except for surface treatment personnel, who had a considerable increase in risk scores.

On production facilities, roughnecks undertake four of the six most stressful tasks in 2014, against two out of six in 2013. Similarly on mobile facilities, roughnecks perform five out of the six most stressful tasks, against two out of six in 2013.

For production facilities, surface treatment personnel are the group with the best reporting overall. This is also the group with the best reporting of all groups in terms of establishing binding plans, measures implemented according to plan and user involvement. Together with catering, this group also reports best in relation to formalised working hours restrictions. In 2013, it was roughnecks who were reported best in terms of establishing binding plans, measures implemented according to plan, user involvement, and ergonomic expertise in relation to implementation of measures. In 2014, however, this is the group that comes out worst in relation to all these factors.

For mobile facilities, it is catering that scores best on all management factors. The use of ergonomic expertise in the RNNP reporting stands out as the question all responded positively to, at nearly 100%. And what clearly stands out as worst for all groups is whether binding plans have been established. For both roughnecks and mechanics, there is a noticeable fall in the proportion of established binding plans compared with 2013. But for these groups too, one can see an increase in reporting on the use of ergonomic expertise in connection with the implementation of measures and of formalised workings hours restrictions compared with 2013.

## 10. At-risks groups in the petroleum industry – analyses of risk exposure using questionnaire data

At-risk groups were among the PSA's main priorities from 2007 to 2014. The focus on at-risk groups stems from audits and various surveys having shown that risk is unevenly divided between personnel groups in the petroleum industry. In many cases, at-risk groups have more demanding working conditions than others, for example in relation to their affiliation (temporary employees, contractors), working hours and rest schemes, physical and psycho-social working environment exposure, time and production requirements, and proximity to various forms of working environment and major accident risks.

In 2014, a detailed survey was made using RNNP questionnaire data concerning whether or how different forms of HSE risk are distributed between different groups. The purpose of the study was to: 1) Investigate how the risk scenario varies among different groups over time, 2) Examine potential relationships between HSE factors linked to the physical and psycho-social working environment and safety climate, and negative outcomes such as work accidents involving personal injury, work-related sickness absence and health complaints, and 3) Perform group interviews with resources from management, employees and technical experts.

### 10.1 Selection and methodology

The questionnaire-based survey is carried out every other year and comprises data from the period 2001-2013 for offshore activities and the period 2007-2013 for onshore installations. Despite a rather low response rate (approx. 30%), from year to year the selection is relatively stable over a range of variables such as gender, age, facility, area of work, ratio between operators and contractors, permanent and temporary employees and proportion with managerial responsibilities. This provides a good basis for comparison for questionnaire analyses from year to year. The questionnaire-based surveys also comprise a large number of people, which helps make the data basis robust.

In the quantitative analyses, the SPSS data analysis tool was used. With the aid of factor analysis, 14 different HSE indexes were established: Physical working environment (3 factors), Psycho-social working environment (6 factors) and Safety climate (5 factors). Logistic regression analysis was performed to investigate the relationships between a range of background variables, HSE factors and two self-reported outcome measures: Work accidents involving personal injury and work-related sickness absence. Separate analyses were also performed for offshore employees and the onshore facilities, as well as examining trends over time.

In addition, qualitative data was obtained in the form of two group interviews with a total of six people. These were from both the contractor and operator sides and included managers, employee representatives and technical experts. The interviewees were sent the results of our analyses in advance so that they could form an opinion of what the results showed and what their underlying causes might be. The aim of the interviews was for the group to reflect on and interpret the results from the questionnaire data. In addition, the group was to identify potential areas of improvement and propose measures to promote change.

### 10.2 Background variables, factors and outcome measures

Below is a brief review of the key background variables investigated in detail, the factors established and a description and assessment of the outcome measures used. For a more thorough description, see the main report.

#### BACKGROUND VARIABLES:

Examples of background variables that were investigated in detail are: sex, age, nationality, education, managerial responsibility, position, permanent/temporary employment, fixed/mobile facilities, experience of downsizing, job security, operator/contractor.

#### 14 FACTORS (HSE INDEXES):

*Physical working environment:* Physical exposure (noise/vibration, two questions), Chemical exposure (two questions), Ergonomic stress (four questions)

*Psycho-social working environment:* Stressful job requirements (three questions), Management support (three questions), Participation (three questions), Support from colleagues (two questions) and Working hours (four questions).

*Safety climate:* Safety prioritisation (six questions), Safety management and commitment (six questions), HSE versus production (four questions), Mastery (four questions) and Competence (four questions).

#### OUTCOME MEASURES:

*Self-reporting of work accidents and personal injury:* In the questionnaire-based surveys, the respondents were asked to say if they had been exposed to a work accident involving personal injury during the last year while they were on the facility/at the plant. The possible responses were yes/no. The figures for injuries reported to the PSA are lower than those reported in the questionnaires. In this context, it should be noted that self-reporting in the questionnaire may also include personal injuries that are not necessarily reportable to the PSA, including first aid injuries and off-work injuries. How the respondent interprets the question may therefore be significant, but it does appear as if the threshold for reporting personal injuries to a manager or nurse at the place of work may be somewhat higher than that for reporting a work accident in the questionnaire.

*Self-reporting of work-related sickness absence:* The questionnaire asked whether, during the last year, the respondent had been away from work due to his/her own sickness. In addition, those who had been off sick were asked to assess whether the sickness absence was wholly or partially caused by their work situation. It is important to note that here we are talking about the amount of self-reported sickness absence and self-assessment of whether the sickness absence is caused by the work situation or not. The causes of sickness absence are a complex interaction between conditions at work, general state of health, social factors, etc. To a degree, an assessment of whether the sickness absence is wholly or partly related to work will depend on whether the respondent is aware of factors in the working environment that may be relevant for the illness in question. The results must accordingly be evaluated in the light of such uncertainties.

*Self-reporting of whether health complaints are work-related:* The respondents were asked to tick against 14 questions if, in recent months, they had suffered from the following: impaired hearing, tinnitus, headache, neck/shoulder/arm pains, back pains, knee/hip pains, eye complaints, skin complaints, Raynaud's phenomenon (white finger), allergic reactions/hypersensitivity, gastro-intestinal problems, respiratory complaints, cardiovascular abnormalities, mental disorders. They were to specify the degree of the health complaint using the following scale: 1=unafflicted, 2=slightly afflicted, 3=quite afflicted and 4=very afflicted. In addition, they were asked to tick if they thought that the complaint was wholly or partially caused by their work situation. A summary variable was then constructed for self-determined health complaints which was augmented by "1" for each question where the individuals stated that the health complaint was wholly or partially caused by their work situation. In the analyses, closer attention was paid to those who reported that the health complaints were wholly or partially caused by their work situation. It is worth remarking here too that there is uncertainty associated with the self-reporting of work-related health complaints. These are complex phenomena, and it is difficult to know precisely what the respondents based their assessments on. The self-assessments must not be interpreted on a par with, for example, work-related illness, which entails more formal reporting processes and expert assessments. These outcomes measure whether the individuals themselves believe that their health complaints are due to their work situation. The results must be interpreted in the light of these circumstances and uncertainties.

### 10.3 Construction of variable – At-risk positions versus other positions

Based on the PSA's experiences of working on and monitoring at-risk groups, concerning which positions are "typical" at-risk positions and which position categories are subject to the highest proportion of work accidents involving personal injury, work-related sickness absence and health complaints, a new variable was constructed, broken down into two categories: At-risk positions and Others positions. This variable was used in subsequent analyses. The "At-risk positions" category included the following: Roughnecks, derrickmen, shaker operator, catering, insulator, iron worker/formwork carpenter, surface treatment personnel/painter, mechanic, process and operations technician, cement worker, scaffolder and rope access technician, welder and sheet metal worker, drilling and well technician/casing operator/wireline operator. At-risk positions comprise around 30% of the selection.

### 10.4 Results

The results showed relationships between self-reporting of all HSE factors and our self-reported outcome measures: work accidents involving personal injury, work-related sickness absence and health complaints caused by one's work situation. Furthermore, individual positions were more at risk than others, young people more than older people, and there were differences between operators' and contractors' employees, between temporary and permanent staff, and between Norwegian and non-Norwegian personnel. There were also clear relationships between experiencing reorganisation, downsizing and redundancy processes, and the likelihood of being at risk of a work accident involving personal injury. From 2009 onwards, the results for at-risk groups show a negative trend in this area. This indicates that the work to improve the situation for at-risk groups is not on target. These are also important results given that the industry is in a phase of considerable change, and that such processes entail higher uncertainty that needs to be taken into account. This is an area that has been discussed in previous research on the relationship between employee conditions and safety (Mayhew et al., 1997; Collinson, 1999; Mayhew & Quinlan, 2001; Clarke, 2003; Quinlan & Bohle, 2003). This finding applies to both offshore and onshore facilities.

Factor analysis is a way of compiling many factors into a few overarching categories. For this study, 14 HSE factors were defined based on the questions in the RNNP questionnaire. These were divided into physical working environment psycho-social working environment and safety climate. The questionnaire data from RNNP constitute a unique source in terms of providing information about how employees offshore and on land experience and assess matters of importance for health, the working environment and safety. It is reasonable to assume that there is a relationship between how we ourselves assess such HSE factors in our own workplaces and different outcome measures. This assumption is reflected and confirmed in the results. We find clear relationships between those who have negative assessments of the HSE factors and those who exhibit a higher proportion of reporting of negative outcomes for personal injuries, work-related sickness absence and work-related health complaints – both offshore and onshore. This correlation may also be formulated conversely: the more positive the assessments of the HSE factors, the less likelihood the respondent has for reporting negatively on the outcome measures. One conclusion is that the factors may help provide an indication of which groups are at risk and what this entails. One would then be able to implement targeted initiatives.

The group interviews with participants from the contractor and operator sides, employee representatives and technical experts emphasised the importance of establishing good forums for the exchange of experience, being focused on late effects relating to exposure at work, working on challenges associated with new technology and readiness to invest, contractual conditions, hired labour in a tight labour market and challenges associated with losing key expertise during recessions. The informants also asserted that the PSA's focus on at-risk groups has led to work to improve their situation being placed on the agendas of industry participants. The sectoral project for noise reduction headed by the Norwegian Oil and Gas Association was mentioned as one positive example. Also emphasised was the importance of having a driving force for improving the conditions of at-risk groups, so that the active efforts to improve the work situation for these groups are not lost.



The results consistently show that risk is over-represented among certain groups, in terms of higher exposure to factors that may be stressful (outcomes of accidents involving personal injury, work-related sickness absence and work-related health complaints). The overall trend for the outcome measures of work accidents involving personal injury, work-related sickness absence and health complaints is upward from 2009 onwards. This means that the number of such incidents appears to be rising from year to year.

There is some variation in the risk trend among different groups over time, but one key tendency is that the differences and the accumulation of risk persist over time for the majority of groups in this study. This applies not least to those in *at-risk positions*, and those who have experienced downsizing or reorganisation – both offshore and onshore. This means that risk not only clusters in certain groups, but these groups appear to be especially vulnerable year after year. On the basis of data from the questionnaires, one conclusion must be that work on at-risk groups has not achieved its goal. This should therefore continue to be a focus area both for the authorities and the industry.

When it comes to interpreting results of statistical correlations from this study, it is important not to draw overly firm conclusions. The relationship between cause and effect is often highly complex, and it is important to take this into account both when interpreting results and instigating measures. We have also remarked that account must be taken of uncertainties in the way our outcome measures are interpreted by respondents, and that there is not necessarily a one-to-one relationship between, for example, enduring a reorganisation process and being at risk of a work accident involving personal injury. In other words, X does not necessarily lead to Y, and the relationship between background variables and outcome variables may be affected by a range of factors (individual, underlying, and interacting) which we did not or could not take account of in this study. The results nonetheless present a picture of which risk factors should be given attention and taken account of in one's own improvement work.

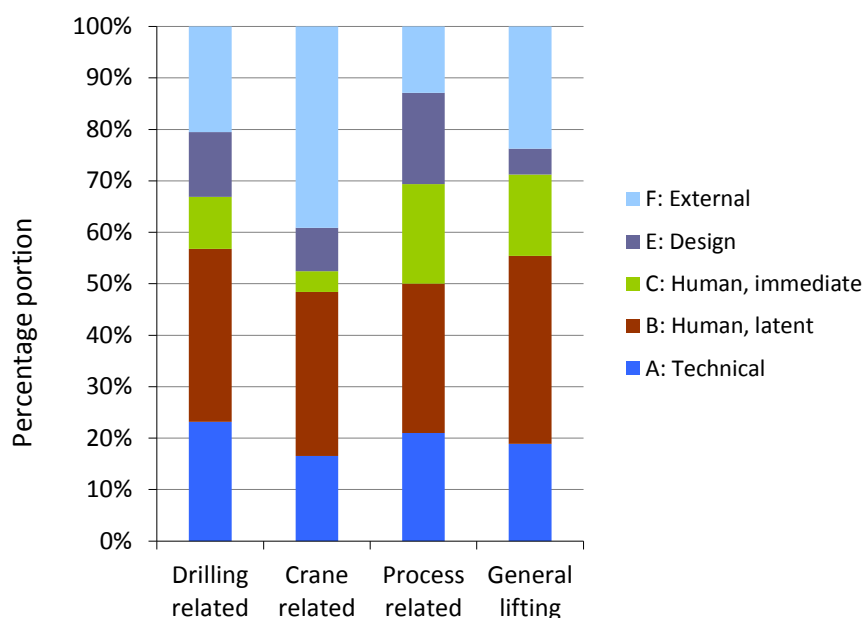
## 11. Other indicators

### 11.1 DFU21 Falling objects

During the period 2002-2014, an average of 219 incidents related to falling objects were reported to RNNP each year. In 2014, a total of 238 incidents were reported, somewhat lower than the previous year's reporting of 258 incidents.

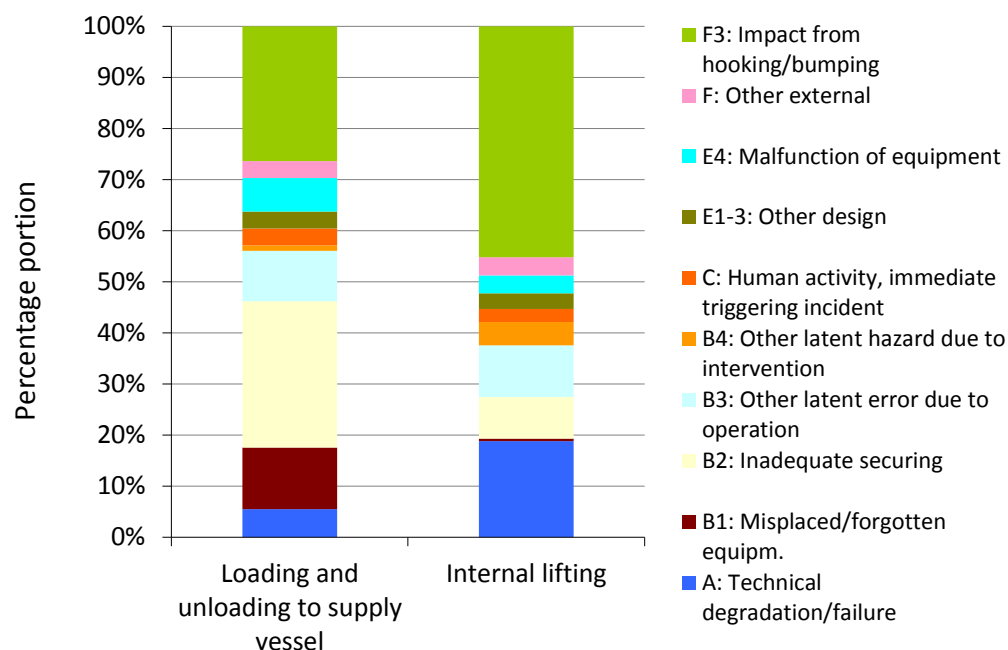
An analysis was conducted to categorise the incidents in accordance with initiating causes. The period 2006-2014 was assessed primarily. The categorisation was performed in accordance with the category model developed in the BORA project; see the main report. This method was originally developed to classify hydrocarbon leaks, but has been generalised and adapted for use on incidents with falling objects.

Figure 35 shows the distribution of incidents in main categories of work processes. The allocation of causes is different for the different work processes. For crane-related incidents, causal categories F and B dominate: External factors and Human activity which introduces a latent hazard. Incidents involving falling objects relating to crane-related work processes are also particularly interesting since the incidents are concentrated in the two highest energy classes.



**Figure 35 Triggering causes by main categories of work processes, 2002-2014**

Figure 36 presents a detailed overview of causes of falling objects with the work processes of loading and offloading operations (from vessels) and lifting that takes place internally on a facility. The data for these work processes included registered incidents dating back to 2002. The F3 category – effects from collisions/hooks represents a relatively large proportion of the incidents in the main category of crane-related work processes. A large share of these incidents can be found within lifting activities that take place internally on the facility. A more comprehensive analysis can be found in the main report.



**Figure 36** *Triggering causes by detailed categories of work processes, 2002-2014*

### 11.2 Other DFU

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, 2015a. Trends in the risk level on the Norwegian Continental Shelf, Main report, 25/04/2015. The most important abbreviations in this report are:

CODAM	Database for damage to structures and subsea facilities
DDRS/CDRS	Database for drilling and well operations
DFU	Defined hazard and accident situations
PM	Preventive maintenance
GM	Metacentric height
HSE	Health, safety and the environment
KPI	Key performance indicator
CM	Corrective maintenance
NPD	Norwegian Petroleum Directorate
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, 2015a. Trends in the risk level on the Norwegian Continental Shelf, Main report, 24/04/2015

PSA, 2015b. Developments in the risk level - onshore facilities in the Norwegian petroleum activities, 24/04/2015