SUMMARY REPORT 2010 - NORWEGIAN CONTINENTAL SHELF

TRENDS IN RISK LEVEL

IN THE PETROLEUM ACTIVITY

PETROLEUM SAFETY AUTHORITY
NORWAY

Foreword

Trends in risk levels in the petroleum industry are not only a matter of concern to everyone involved in the industry but are also of interest to the public at large. It was therefore a logical and important step to establish a structure for measuring the effect of the collective HES work in the industry.

As a tool, RNNP has undergone substantial development since its initial years 1999/2000 (the first report was issued in 2001). This development has taken place in the context of collaboration between the partners in the industry and consensus that the chosen approach is sensible and rational with a view to establishing a basis for a common understanding of the level of risk. In 2010 the first report on acute discharges to sea was published. The report was based on a combination of RNNP data and data from OLF's Environmental Web database. Because of the period required for the collection of data for the Environmental Web, the RNNP report on acute discharges will not be published until the autumn. The intention is that this should also be an annual report.

The petroleum industry has a high level of competence in the field of HES. We have sought to draw on this competence by making the process an open one and inviting key resource persons from operating companies, shipping companies, the Civil Aviation Authority, helicopter operators, consultancy firms, research and teaching institutions to contribute.

Objectivity and credibility are key words if opinions on safety and the working environment are to carry any weight. This is conditional on all the parties concurring that the methodology offers a logical approach and that the results create value. Their joint ownership of processes and results is therefore important. To promote continuing active ownership of the process, a reference group representing the partners in the industry was constituted in 2009 with the mandate of contributing to the further development of the work.

Many people, both in and outside the industry, have contributed to the project. It would take too long to list them all but I should like to mention in particular the positive response we have met with in all our contacts with the parties concerned in connection with the implementation and continuing development of the work.

Stavanger, 27. April 2011

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Part 1: Purpose and conclusions

1. Purpose and limitations

1.1 Purpose

The project ”Trends in Risk Levels – Norwegian Continental Shelf” was launched in year 2000. The Norwegian petroleum industry has evolved from a development phase encompassing many major fields to one in which operation of facilities dominates. Among factors marking the industry today are problems associated with older facilities, exploration and development in environmentally sensitive areas and the development of smaller and economically less viable fields. The future development of petroleum activities must be pursued in a perspective of continuing improvements in health, environment and safety (HES). Measuring the effect of all safety work in these activities is therefore an important contribution. Changes are also taking place in relation to participation, with increasing numbers of new players making their entry on the Norwegian Continental Shelf.

The industry has traditionally used selected indicators to illustrate safety trends in petroleum activities. An indicator based on the frequency of occupational accidents resulting in lost working time has been particularly widely applied. These indicators give only a partial picture of the overall safety situation. The preference in recent years has been for a range of indicators to be used to measure trends in certain key HES factors.

The Petroleum Safety Authority wishes to form a nuanced picture of trends in risk level based on information from different sides of the activities, with a view to measuring the effects of safety work in the industry as a whole.

1.2 Objectives

The aim of the work is to:

- Measure the impact of HES-related measures in the petroleum industry.
- Help to identify areas which are critical for HES and in which priority must be given to identifying causes in order to prevent unplanned events and accidents.
- Improve understanding of the possible causes of accidents and their relative significance in the context of risk, among other reasons to create a reliable decision-making platform for the industry and authorities in planning preventive safety and emergency preparedness measures.

The work will also help to identify potential areas for regulatory changes and for research and development.

1.3 Important limitations

The work focuses on risk to personnel and covers major accidents, occupational accidents and working environment factors. Both qualitative and quantitative indicators are used. For the present report, a qualitative study has been made of hydrocarbon leaks, their causes and preventive measures.

- The activity is limited to factors which fall under the PSA’s area of authority in regard to safety and the working environment, and includes all helicopter transport of personnel, in cooperation with the Civil Aviation Authority Norway and helicopter operators on the Norwegian Continental Shelf. The work covers the following areas:
- All production installations and mobile units on the Norwegian Continental Shelf, including subsea installations
- Transport of personnel by helicopter between helicopter terminal and installation (point of departure to point of landing).
- The use of vessels inside the safety zone around the installations.

Eight specified land facilities have been included since 1.1.2006. Data acquisition started from that date and separate annual reports have been published for the last five years, with results and analyses for land facilities. A separate report was issued for the first time in 2010 on acute discharges to sea from the offshore petroleum industry.

2. Conclusions

We endeavour in this work to measure trends in risk level in relation to safety, the working environment and the external environment[1] through applying a range of relevant indicators. Analysis is based on the triangulation principle i.e. the use of different measurement tools to measure the same phenomenon, in this case trends in risk level.

Our primary focus is on trends. It is to be expected that some indicators, particularly within a limited topic field, will show sometimes substantial variation from year to year. Accordingly, and especially in view of the government's goal that the Norwegian petroleum industry should be a world leader in HES, the industry should direct its efforts towards achieving positive long-term trends.

Ideally, it should be possible to arrive at a synthesised conclusion based on information from all measurements. In practice this often proves complicated, partly because the indicators reflect HES factors on sometimes widely-divergent levels. In this survey we concentrate primarily on risk indicators relating to:

- Major accidents, including helicopter-related accidents
- Barriers, particularly those relating to major accidents
- Serious injury to personnel
- Occupational illness and injury
    - Chemical work environment
    - Noise-related injury
    - The physical work environment
- Qualitative evaluations relevant to the above.

In recent years the industry has focused much of its attention on reducing the number of hydrocarbon leaks. Clear reduction targets have been set on several occasions: first a maximum of 20 leaks greater than 0.1 kg/sec in 2005, next maximum 10 leaks in 2008 thereafter a further reduction. The first target was met in 2005 and in 2007 10 leaks of this type were registered. In 2008 to 2010 there was again an increase: 14 in 2008, 15 in 2009 and14 in 2010. In 2010 it was particularly leaks in the category 0.1–1 kg/s where this increase occurred. In 2010 there was also one recorded instance of a leak greater than 10 kg/s. A comparison of leak frequency per operator continues to show that there are relatively substantial differences between operators. In addition, a comparison of leak frequency on the Norwegian and British Continental Shelf shows that there is potential for reduction on the Norwegian Continental Shelf. In other words, the targets for the period 2008-2010 have not been met and the trend is not one of continuous improvement. More directed, and not least continuous, effort is required to reverse the trend.

In 2010 a qualitative study was performed in the context of the negative trend in recent years relating to reported hydrocarbon leaks. In the last few years a number of studies have been made at national and international level and many accident investigations conducted following events, to establish the causes of hydrocarbon leaks and relevant risk-reducing measures. The Petroleum Safety Authority (PSA) accordingly expressed the wish for a study to be performed in which this documentation was to be used as a basis for analysing causal factors and

[1] Data collected through RNNP is used together with data from Environmental Web database in order to consider discharges to sea. The results are presented in a separate report published in the autumn.

measures relating to hydrocarbon leaks in the Norwegian petroleum activities. A perusal of investigation reports and other material gives a picture of (1) the causes identified for hydrocarbon leaks in the Norwegian petroleum activities, (2) proposed preventive measures and (3) if there is clear correspondence between identified causes and proposed measures. From a scrutiny of the causal factors and proposed measures contained in these investigation reports, four key challenges have been identified in the work of reducing the number of hydrocarbon leaks. These relate to: ”design factors as a major cause”, ”learning from previous events”, ”formulation of concrete measures” and ”risk assessments and analyses”.

The indicator for well control events also pointed to a consistently positive trend in the period up to 2008. In the period 2008–2010 there is a further increase, from 11 events in 2008 to 28 in 2010. Even when the number of events is normalised against activity level (the number of wells drilled), the increase is clear. An assessment of the contribution to risk, weighed in relation to its potential contribution to loss of life, shows that well control events in 2009 and 2010 make a clearly higher contribution.

The number of events involving vessels on collision course continues to show a positive trend. The level in 2010 is significantly lower than the mean value for the period 2002–2009. In this case the monitoring of the zones around the installations from dedicated traffic centres must be acknowledged as a definite contributory factor. In the last ten years there have been 28 collisions on the Norwegian Continental Shelf between installations and visiting vessels. These events are due to weaknesses in the organisation of work and responsibility, deficient training of relevant personnel and technical equipment failure. Six of the reported events had major hazard potential. Responsibility for the events is attributable to operators, shipowners and crew. In other words, the events result not from any single cause but from a number of factors. Substantial improvement is needed in terms of how vessels are operated and followed up. There was a reduction in the number of collisions in the period 1998-2001, but the period 2004-2010 shows an increase in the number of serious events.

The other indicators reflecting incidents with major accident potential show a stable level, with relatively minor changes in 2010.

The total indicator, which reflects potential for loss of life if registered incidents develop into actual events, is a product of frequency (probability) and potential consequence. A risk indicator based on history is not an expression of risk but can be used to evaluate trends in parameters that contribute to risk. A positive development in an underlying trend for this indicator therefore suggests that a greater degree of control is being gained over factors contributing to risk.

In the last 5–6 years the total indicator, for both production installations and mobile units, has flattened out at a lower level than in the foregoing period. An overarching goal of a continuous risk-reduction process could possibly have shown a consistent reduction in this indicator. Since individual events with large potential influence the indicator to a relatively marked degree from year to year, the analysis is based on 3-year rolling averages.

Helicopter-related risk accounts for a major part of the total exposure to risk to which offshore personnel are exposed. The helicopter indicators used in this work were extensively modified in 2009/2010 in order to better reflect real risk factors associated with the events covered in the survey. The steps taken include the establishment of an expert group under the RNNP umbrella tasked with evaluating the level of risk associated with the most serious events. The expert group is composed of personnel with competence in relevant disciplines: aviation (pilot), technical and risk.

The last major accident entailing fatalities on the Norwegian Continental Shelf occurred in September 1997 in connection with the helicopter accident off Brønnøysund. In 2009 there were several serious helicopter accidents in the petroleum industry worldwide.

The indicator reflecting the most serious events, and evaluated by the expert group, shows a positive trend from 2009 to 2010. Among other factors, it may be assumed that this trend

reflects the introduction of new types of helicopter. The number of ATM-related events (air traffic management), particularly in connection with deficient radio cover, shows an increasing trend over the last three years.
The industry is now turning its attention to pro-active (leading) indicators, i.e. indicators that can provide information about robustness in relation to capacity for withstanding potential events. Our barrier indicators are examples of these. The barrier indicators show that there is substantial variation between the different installations, some of which show relatively poor results for certain barrier systems. On the whole, the average result for all installations is approximately as anticipated but we must remember that the value of these indicators lies primarily on individual installation level, with the exception of some types of safety valves (ESDV, DHSV and BDV) where the number of failures is slightly above the anticipated level. For certain types of barrier elements, for example BOP, the data material still suffers from a considerable degree of uncertainty. On facility level, some installations are observed to deviate substantially from the expected results, a possible indication of a challenge relating to the robustness of the barrier.

For the last two years we have collected data on maintenance management. Normally, data must be acquired over several years to obtain a sufficiently stable set of data. The figures from 2009 and 2010 show that some participants are experiencing challenges in establishing the expected level of maintenance management, seen in the light of the rules and regulations. Mobile units have the greatest challenges.

These challenges relate to the classification of equipment and the extent of outstanding tasks within both preventive and corrective maintenance, including maintenance that is HES-critical.

The indicator for serious injury to personnel points to a positive trend in recent years. Injury frequency is now 0.68 serious cases of injury per million manhours for the Norwegian Continental Shelf as a whole. This is significantly lower than the average for the preceding ten-year period. For production installations there is no clear trend for the last five years, where frequency has varied between 0.65 and 0.87, and in 2010 it is at 0.79. In 2010 there was a decrease in frequency among the contractor personnel group, while operator personnel have experienced an increase. Injury frequency on mobile units shows a marked reduction in 2010 (to 0.42) compared with previous years. In 2010 the frequency of serious injury in connection with drilling and well operations on mobile units was a third of that in corresponding functions on production installations.

The noise exposure indicator shows only a marginal improvement in 2010, despite the fact that both the authorities and the companies have given close attention to the problem. Part of the explanation may be that effective noise-reducing measures take a relatively long time to plan and implement. Data from the survey indicate that most categories of personnel have a noise exposure value above the limit of 83 dBA. A joint project involving the industrial partners and spearheaded by OLF and Norsk Industri is in the process of establishment, with the aim of enhancing risk reduction work.

Indicators for ergonomic factors were reported for the second time this year. A new feature this year is that companies report data for a total of 80 % of all work tasks for each of the relevant personnel categories. This helps to ensure that the indicators give a more correct picture of the total load for each group.

A comparison of the results between production installations and mobile units shows that all groups on mobile units report substantially higher loads in relation to job category. We find substantially higher values for drill floor workers, catering assistants and mechanics on older production installations compared to newer. Surface treatment workers on production installations comprise the group which collectively has the highest score of all groups on offshore and land facilities, while on older installations it is roughnecks who have the highest average score for ergonomic factors.

Part 2: Implementation and scope

3. Implementation

The work done in 2010 is a continuation of previous years' activities over the period 2000–2009, see NPD (2001), NPD (2002), NPD (2003), PSA (2004), PSA (2005), PSA (2006), PSA (2007), PSA (2008), PSA (2009) and PSA (2010). (Complete references are given in the main project report on www.psa.no/rnnp). This year we have applied the same general principles and expanded reporting with special emphasis on the following elements:

- The qualitative study consists of an analysis of the causes of, and follow-up of measures for preventing, hydrocarbon leaks, based on investigation reports from the period 2001–2009 and other material.
- The work of analysing and evaluating data relating to defined situations of hazard and accident has been continued, both for installations and for helicopter transport.
- A substantial quantity of experience data has been acquired for barriers against major accidents and analysed as in the period 2003-2009. Greater weight has been attached to nuances in the data for well barriers.
- Indicators for noise, chemical work environment and ergonomics have been followed up as before.
- Data from onshore facilities have been analysed and presented in a separate report.
- Cases of acute discharges to sea and potential discharges to sea have been analysed and presented in a separate report.

3.1 Implementation of the work

Work on this year's report began in summer 2009 and involved the following participants:

• The Petroleum Safety Authority:	Responsible for implementation and follow-up of the work
• Operator companies and shipping companies:	Contribute data and information about activities on the installations and in the work of adapting the model to land installations, which have been included since 1.1.2006
• Civil Aviation Authority Norway:	Responsible for the reporting of public data on helicopter activities and quality assurance of data, analyses and conclusions
• Helicopter operators:	Provide data and information on activities in the helicopter transport sector
• HES expert group: (selected specialists)	Evaluate methods, databases, views on development, evaluate trends, propose conclusions
• The Safety Forum (representing unions, employers and authorities):	Comment on methods, procedures and results and make recommendations for further work.
• Advisory group (representing unions, employers and authorities):	Joint advisory group for RNNP, to advise the Petroleum Safety Authority on follow-up of the work.

The Petroleum Safety Authority has had support from the following external experts with responsibility for specific aspects of the work:

- Jan Erik Vinnem, Preventor
- Odd J. Tveit
- Jorunn Seljelid, Beate Riise Wagnild, Grethe Lillehammer, Bjørnar Heide, Cecilie Å. Nyrønning, Aud Børsting, Peter Ellevseth, Ole Magnus Nyheim, Sverre Kvalheim, Øystein Skogvang and Terje Dammen, Safetec

- Bodil Mostue, Stein Hauge, SINTEF Teknologi og Samfunn, Trond Kongsvik, Studio Apertura

The PSA working group is composed of: Einar Ravnås, Øyvind Lauridsen, Mette Vintermyr, Birgit Vignes, Arne Kvitrud, Trond Sundby, Jorunn Elise Tharaldsen, Hilde Nilsen, Inger Danielsen, Elisabeth Lootz, Sigvart Zachariassen, Hilde Heber, Åse Larsen, Anne Mette Eide, Hans Spilde, Semsudin Leto and Torleif Husebø.

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

- Evelyn Westvig, Civil Aviation Authority
- Egil Bjelland, Inge Antonsen, CHC Helicopter Service
- Inge Løland, Per Skalleberg, Bristow

Numerous others have also contributed to the implementation of the work.

3.2 Use of risk indicators

Data have been collected for situations of hazard and risk associated with major accidents, occupational accidents and working environment factors, specifically:

- Defined situations of hazard and accident, with the following main categories:
  - Uncontrolled release of hydrocarbons, fires (i.e. process leaks, well events/-shallow gas, riser leaks, other fires)
  - Structural events (i.e. structural damage, collisions, threat of collision)
- Experience data relating to the performance of barriers against major accidents on the installations, including well status data and maintenance management
- Accidents and events in helicopter transport activities
- Occupational accidents
- Noise, chemical work environment and ergonomic factors
- Diver accidents
- Other DFUs with minor consequences or significance for emergency preparedness

The term major accident is used at various points in these reports. There is no universally agreed definition of the term but the following definitions are often used and coincide with the definition applied in this report:

- Major accident is an accident (i.e. entails a loss) in which at least 5 persons may be exposed.
- Major accident is an accident caused by failure of one or more of the system's integral safety and preparedness barriers.

In the light of the definition of major accident in the Seveso II directive, the definition used here is closer to that of a 'large accident'.

Data acquisition for the DFUs relating to major accidents is based partly on established Petroleum Safety Authority databases (CODAM, DDRS, etc.) but also includes to a considerable extent data acquired in cooperation with the operator companies and shipping companies. All event data have been quality assured by e.g. checking them against the event register and other Petroleum Safety Authority databases.

Table 1 shows an overview of the 19 DFUs, and the data sources used. The industry has applied the same categories for data registration through the Synergi database.

Table 1 List of DFUs and data sources

DFU	*DFU description*	*Data sources*
1	Non-ignited hydrocarbon leaks	Data acquisition*
2	Ignited hydrocarbon leaks	Data acquisition*
3	Well kicks/loss of well control	DDRS/CDRS (PSA)
4	Fire/explosion in other areas, flammable liquids	Data acquisition*
5	Vessel on collision course	Data acquisition*
6	Drifting object	Data acquisition*
7	Collision with field-related vessel/installation/shuttle tanker	CODAM (PSA)
8	Structural damage to platform/stability/anchoring/positioning failure	CODAM (PSA) + industry
9	Leaking from subsea production systems/pipelines/risers/flowlines/loading buoys/loading hoses	CODAM (PSA)
10	Damage to subsea production equipment/pipeline systems/diving equipment caused by fishing gear	CODAM (PSA)
11	Evacuation (precautionary/emergency evacuation)	Data acquisition*
12	Helicopter crash/emergency landing on/near installation	Data acquisition*
13	Man overboard	Data acquisition*
14	Injury to personnel	PIP (PSA)
15	Occupational illness	Data acquisition*
16	Total power failure	Data acquisition*
18	Diving accident	DSYS (PSA)
19	H_2S emission	Data acquisition*
21	Falling object	Data acquisition*

* Data acquired with the cooperation of operator companies

3.3 Trends in activity level

Figure 1 and Figure 2 show trends over the period 1996-2010 for production and exploration activities, of those parameters used for normalisation against activity level (all figures are relative to the status in year 2000, which is put at 1.0). Appendix A of the Main Report (PSA, 2011a) presents the base data in detail. Errors in the database in previous reports have been corrected.

Changes in activity level in relation to the individual parameters are dissimilar, the number of manhours on production installations having marginally increased (approx.1 %), while there is a clear decrease for mobile units. On mobile units the variations from year to year are even larger than for production installations. The presentation of DFUs or risk may therefore differ according to whether we use absolute or ”normalised” values, depending on normalisation parameters. Normalised values have been presented in the main.

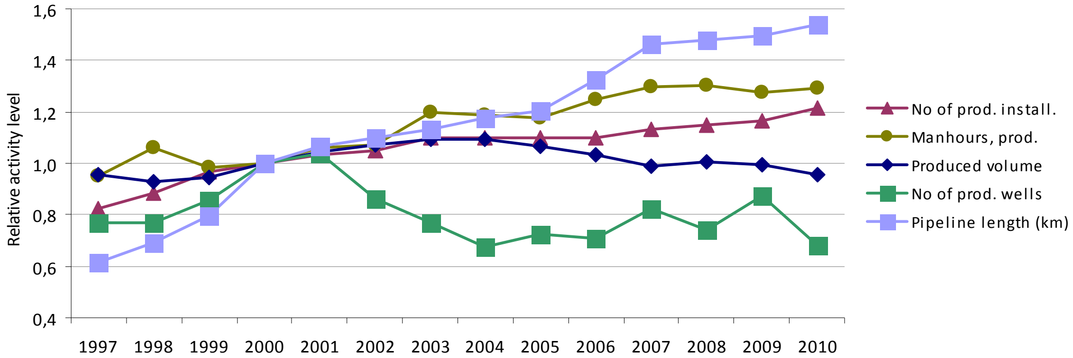


Figure 1 Trends in activity level, production

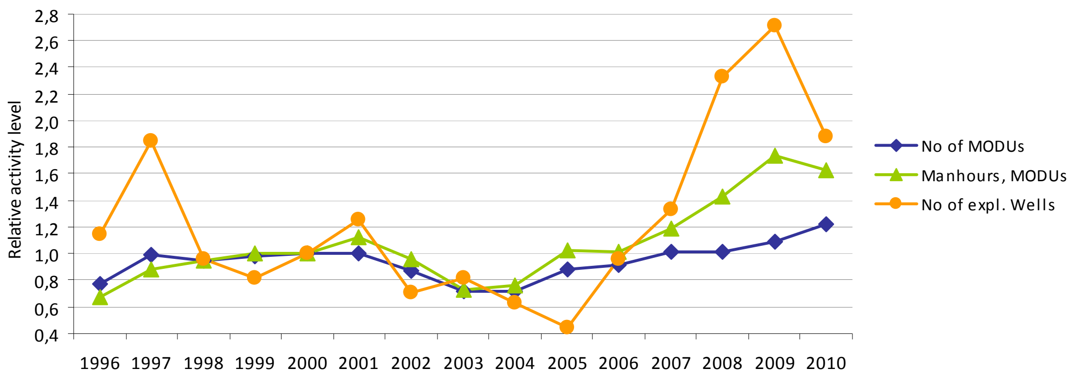


Figure 2 Trends in activity level, exploration

A corresponding activity overview for helicopter transport is shown in Subsection 6.1.

3.4 Documentation

The analyses, evaluations and results are documented as follows:

- Summary Report – Norwegian Continental Shelf for 2010 (Norwegian and English versions)
- Project Report – Norwegian Continental Shelf for 2010
- Land Facilities Report for 2010
- Acute Discharges to Sea Report – Norwegian Continental Shelf for 2010, to be published autumn 2011

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

4. Scope

The qualitative study this time consists of a report on the causes of hydrocarbon leaks and appropriate preventive measures.

The statistical analysis methods applied in previous years have been continued, with only minor changes. A new indicator for maintenance was introduced in 2009 and continued in 2010, together with new indicators for helicopter risk. The work on serious injury related to occupational accidents has also been continued as in previous years, along with indicators for noise, ergonomic factors and chemicals.

Part 3: Results from 2010

5. Causal factors and measures relating to hydrocarbon leaks on the Norwegian Continental Shelf

The last three years show a negative trend in the number of hydrocarbon leaks reported on offshore production installations. Various studies on national and international level have been performed in recent years, together with many post-event investigations, in the search to identify the causes of hydrocarbon leaks and determine appropriate risk-reducing measures. With this in mind, PSA expressed the wish for a new study to be made, drawing on this documentation, which would analyse the causal factors of hydrocarbon leaks on the Norwegian Continental Shelf and propose appropriate measures. The research group from SINTEF/Studio Apertura has scrutinised 42 investigation reports (2002–2010), diverse reports from various research communities, consultancies and authorities, 33 research articles and descriptions of measures considered by the operator companies' own specialists to be the most important contribution to risk reduction.

This perusal of investigation reports gives a picture of (1) what causes can be put forward to explain the occurrence of hydrocarbon leaks on the Norwegian Continental Shelf, (2) what measures have been proposed and (3) if there is good correspondence between identified causes and these measures. From a reading of the causal factors and proposed measures contained in investigation reports, four key challenges have emerged in association with the work of reducing the number of hydrocarbon leaks: ”design factors as a major cause”, ”learning from previous events”, ”formulation of concrete measures” and ”risk assessments and analyses”.

The following five categories of direct/triggering causes have been found to be the most important in our study of the documentation:
'Factors relating to the technical design of the system' (24 %), 'Technical condition/aging/wear and tear' (21 %), 'Wrong actions stemming from non-observance of prevailing practice/procedures' (14 %), 'Wrong actions of an negligent/careless nature' (11 %), 'Cognitive errors (lack of competence and/or poor understanding of risk)' (9 %).

Distributed over the categories of human factors, technology and organisation, our scrutiny of direct/triggering factors shows that 48 % of direct causes are technical in origin and 41 % human, while only 11 % are classified as organisational in nature.

With reference to underlying causes the picture is different. Here the distribution is 65 % organisational, 21 % human and 14 % technical. No single causal factors dominate this picture. The four most frequent underlying causes have been found on the other hand to be: 'Factors relating to the technical design of the system' (11 %), 'Cognitive errors resulting from lack of competence/training and/or poor understanding of risk' (10 %), 'Poor communication/cooperation/interfaces/conflicting objectives' (9 %).

Of the measures described in the investigation reports, 79 % are classified as being of an organisational nature, 20 % technological and 1 % people-related. The most frequent measures registered are: 'Control/checks/verification' (29 %), 'Procedures/documentation' (15 %), 'Technical design' (11 %) and 'Technical condition etc.' (6 %), 'Competence/training/-understanding of risk' (10 %).

A general observation is that many measures are organisational in character while relatively few are technical. In other words, there is no noticeable degree of correspondence between identified causes, particularly triggering factors, and the measures specified. A further observation in regard to measures is that these often lack specificity and require substantial additional work to give them concrete form.

Four areas for improvement have been identified with regard to the reduction of hydrocarbon leaks:

- The adoption of a more offensive approach to designing or re-designing technical solutions where these are deficient, rather than accepting and adapting to them.
- Appropriate learning and experience transfer and the systematic and efficient use of information from event databases, investigations, indicators and other sources relevant to preventive work.
- Definition of precise and concrete measures to be taken in the wake of investigations, an area in which there is substantial room for improvement.
- The implementation and application of risk assessments and analyses of the risk of hydrocarbon leaks.

6. Status and trends – DFU12, helicopter events

Cooperation with Civil Aviation Authority Norway and helicopter operators continued in 2010. Aviation data collected from the relevant helicopter operators cover event type, risk class, degree of severity, type of flight, phase, helicopter type and information about points of departure and arrival. The Main Report (PSA, 2011a) contains further details of scope, limitations and definitions. The last major accident involving fatalities on the Norwegian Continental Shelf was in September 1997 in connection with the helicopter accident off Brønnøysund.

In 2009 changes were made in two of the three event indicators which had been in use for several years, and these modified indicators were applied again in 2010 while the activity indicators have continued unchanged. The activity indicators reflect how exposure to helicopter risk evolves and is thus a more proactive indicator. These indicators are explained in detail in the Main Report. For one of the event indicators, work has been done in 2010 on re-analysing data for the period 2006–2008, in order to incorporate data for the new indicator into a five-year period. The new indicators point to interesting trends, even though data are currently limited in scope, with resultant larger uncertainty.

6.1 Activity indicators

Figure 3 shows activity indicator 1 (crew change traffic) and activity indicator 2 (shuttle traffic) in number of flight hours and number of person flight hours a year in the period 1999-2010. There has been an increase in crew change traffic in recent years. Data for 2008 and 2009 have been partly amended. There was a slight decrease in the volume of shuttle traffic for the period taken as a whole.

Crew change traffic **Shuttle traffic**

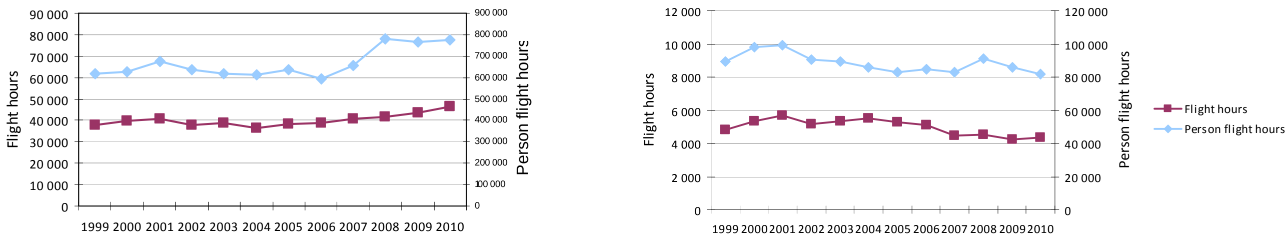


Figure 3 Volume of crew change traffic and shuttle traffic, person flight hours and flight hours, 1999-2010

Activity indicator 1, volume of crew change traffic per year, must be seen in the context of activity level on the Norwegian Continental Shelf. There is a continuing slight increase in the number of manhours on production installations while the number of manhours on mobile units has varied to some degree but with an increase after 2003. There is in general a constant need for transport per manhour, which would indicate an increase in both flight hours and person flight hours. A balancing factor is better use of helicopters and the ability of the new helicopters to take off with a maximum passenger load under practically all weather conditions.

On several installations shuttle traffic is part of the daily routine. The Ekofisk Field has most shuttle traffic activity. To a certain extent, shuttle traffic is flown using larger helicopters than previously, a factor which may go some way to explaining the decrease in the number of flight hours. In 2010 the number of flight hours in association with shuttle traffic is reported as being a little higher than in 2009 (approx. 2.8 %) and the number of person flight hours has fallen (approx. 4.8 %) against the figures for 2009.

6.2 Event indicators

6.2.1 Event indicator 1 – serious incidents

Figur 4 shows the number of events included in a new event indicator 1. From 2009 (as for 2006, 2007 and 2008) the most serious incidents reported by the companies have therefore been scrutinised by an expert group comprising operative and technical personnel from the helicopter and petroleum companies and personnel from PSA's project group, with a view to classifying events on a finer scale, based on the following categories:

- Small remaining safety margin against fatal accident: No remaining barriers
- Medium safety margin against fatal accident: One remaining barrier
- Substantial remaining safety margin against fatal accident: Two (or more) remaining barriers.

Event indicator 1 covers those events/incidents with small or medium remaining margin against fatal accident for passengers, i.e. no barrier or one remaining barrier. In the years 2006 and 2007 there was one event a year with no remaining barriers, while there were two events of this kind in 2008. There were zero events with no remaining barrier against fatal accident in 2009 and 2010. As before, events in the parked phase have not been taken into account.

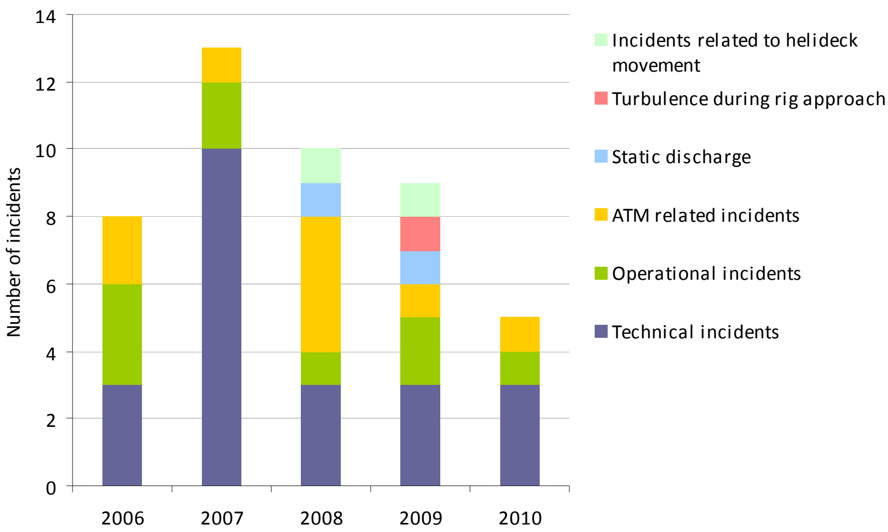


Figure 4 Event indicator 1, events with small or medium remaining safety margin, 2006–10

Six of 13 events in 2007 were associated with the S-92, one of the newest helicopters on the Norwegian Continental Shelf. In terms of traffic, the S-92 stands for approximately 60–70 % of flying hours, while various generations of the Super Puma stand for most of the remaining hours. The number of events associated with the S-92 came to three in 2008, four in 2009 and three in 2010. Of a total of 16 events with the S-92 in the period 2007–2010, nine were due to technical factors while the remainder had operational or other causes combined with strong turbulence from the installation. The EC-225, which is also a new Super Puma helicopter, has had only one event in the same period, caused by technical factors.

6.2.2 Event indicators in relation to cause categories

Event indicator 3 has been replaced from 2009 by event indicators based on cause categories, with the following content:

- Helideck factors
- Erroneous information about the position of the helideck
- Erroneous/incomplete information
- Equipment fault
- Turbulence
- Obstacles in the landing/take-off sector or on deck
- Persons in the restricted sector
- Failure to follow procedures
- Flight control (ATM) aspects
- Collision with birds.

All degrees of severity beyond ”no safety-related consequences” are covered by these indicators. Data are presented in Figure 5–Figure 7 for 2008–2010. For 2008 some events may not have been included but not so many that there is no clear increase up to 2009. In 2010 a sharp reduction in helideck-related events is noted, in all probability a result of the industry’s closer attention to these factors. In contrast, the number of events related to flight control aspects increased in both 2009 and 2010.

On the basis of these cause-related indicators certain areas and factors are mentioned in the Main Report (PSA, 2011a) where an effort should be made to effect improvement.

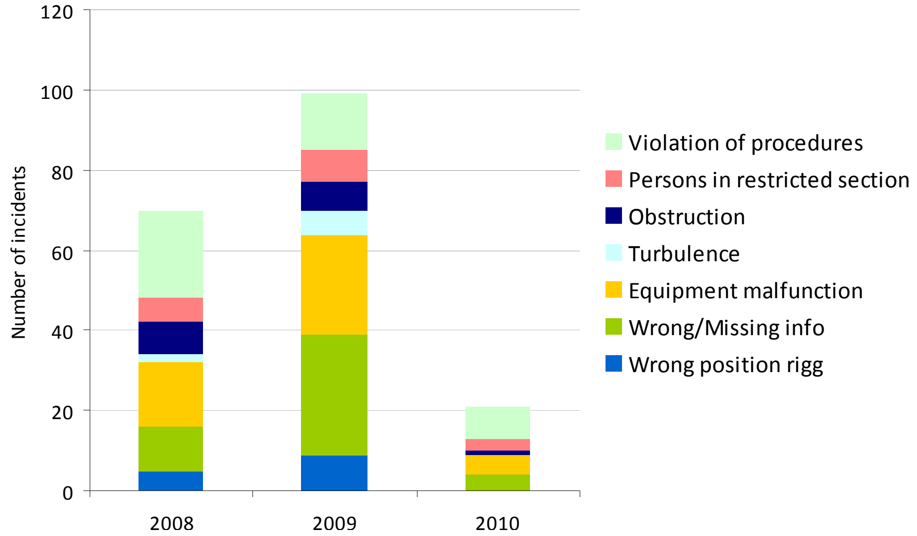


Figure 5 Helideck factors, 2008–10

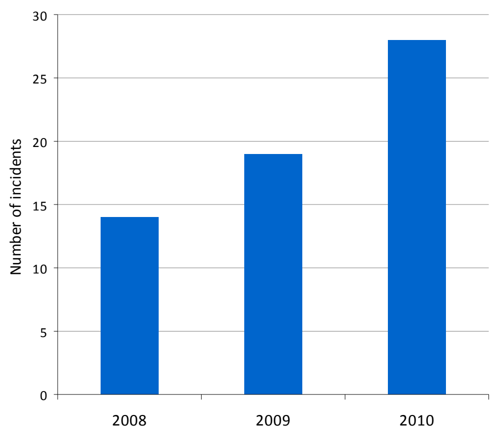


Figure 6 Flight control aspects, 2008–10

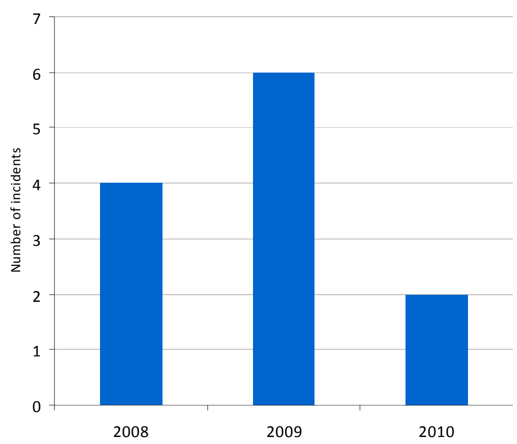


Figure 7 Collision with birds, 2008–10

7. Status and trends – indicators for major accidents on installations

Indicators for major accident risk have been continued from previous years, with emphasis on indicators for events and incidents with major accident potential. Indicators for major accident risk associated with helicopters are discussed in Section 6, and barriers against major accidents in Section 8.

There have been no major accidents, by our definition, on installations on the Norwegian Continental Shelf after 1990. None of the DFUs for major accident risk on installations have entailed fatalities in the period. The last time there were fatalities in association with one of these major accident DFUs was in 1985, with the shallow gas blowout on the rig "West Vanguard"; see also page 13 in connection with the helicopter accident off Brønnøysund. In addition, there have been no cases of ignited hydrocarbon leaks from process systems since 1992, apart from the occasional minor leak with no potential for major accident.

In 2010 there was a very serious accident in the Gulf of Mexico, in which the mobile unit Deepwater Horizon experienced a blowout with almost immediate ignition, followed by explosion and fire. 11 people died in the explosion while the remaining crew were evacuated in two lifeboats, some with serious burn injuries. The rig sank after burning for about one and a half days, and the blowout lasted for almost three months. Two investigation reports have been published to date, and more are being prepared. Norwegian industry, through reports from both OLF and the Petroleum Safety Authority, is drawing lessons from this accident of relevance to the Norwegian Continental Shelf. Potential injury to personnel in the case of any similar accident occurring on the Norwegian Continental Shelf is covered in the DFU 'well control events', see Figure 8 and the weight given to events of this nature.

The most important individual indicators for production installations and mobile units are discussed in Subsection 7.2. The other DFUs are discussed in the Main Report. The indicator for total risk is discussed in Subsection 7.3.

7.1 DFUs related to major accident risk

Figure 8 shows the trend in the number of reported DFUs in the period 1996–2010. It is important to emphasise that these DFUs vary widely in their contribution to risk.

The average level after 2000 is higher than that in the period 1996-99. The level decreased consistently from 2002 to 2007 and in 2007 was on a par with that in the period 1996-99. The number of incidents increased by 10–15 % in the period 2008–10 but remains below the level for 2000–06. In particular DFU5 (vessel on collision course) was substantially underreported up to 2001, in our view. The increase shown in DFU5 (vessel on collision course) in Figure 8 is not a good indication of risk trend (see the discussion in Subsection 7.2.4). This applies to a lesser extent to the DFUs related to hydrocarbon leaks and loss of well control. Figure 8 shows that these dominate in number up to 2003 but that the percentage falls to below 50% from and including 2004. From their lowest level in 2007, the DFUs related to hydrocarbon leaks and loss of well control rose again in the period 2008–2010 and are back over 50 % in 2010.

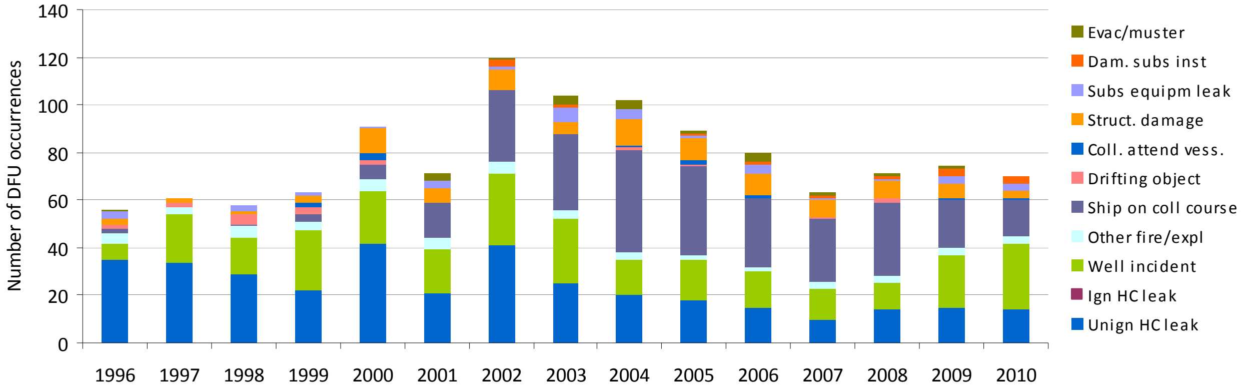


Figure 8 Reported DFUs (1-11) by category

This applies to a lesser extent to the DFUs relating to hydrocarbon leaks and loss of well control. Figure 8 shows that these are dominant in number up to 2003, but the percentage falls to below 50 % from and including 2004. The increase in DFU5 (vessel on collision course) Figure 8 in is not a reliable indication of trends in risk level (see the discussion in Subsection 7.2.4).

7.2 Risk indicators for major accidents

7.2.1 Hydrocarbon leaks in the process area

Figure 9 shows the total number of leaks exceeding 0.1 kg/s in the period 1996–2010. Up to 1999 there was a falling trend, succeeded by a period of large variation from year to year. There was a marked drop from 2002 to 2007, but the number of leaks exceeding 1 kg/s did not decrease to the same extent. After 2007 the number of leaks stabilised at a level 50% above that in 2007, without the industry's objective of a continuous reduction per year being met. The number of leaks exceeding 1kg/s in 2010 is at the lowest recorded level, with one leak in the 1–10 kg/s category and one leak in excess of 10 kg/s. Hydrocarbon leaks are still classified by leak rate in coarse classes as shown in Figure 9, while a finer grading for the period 2001–10 is also shown in the Main Report.

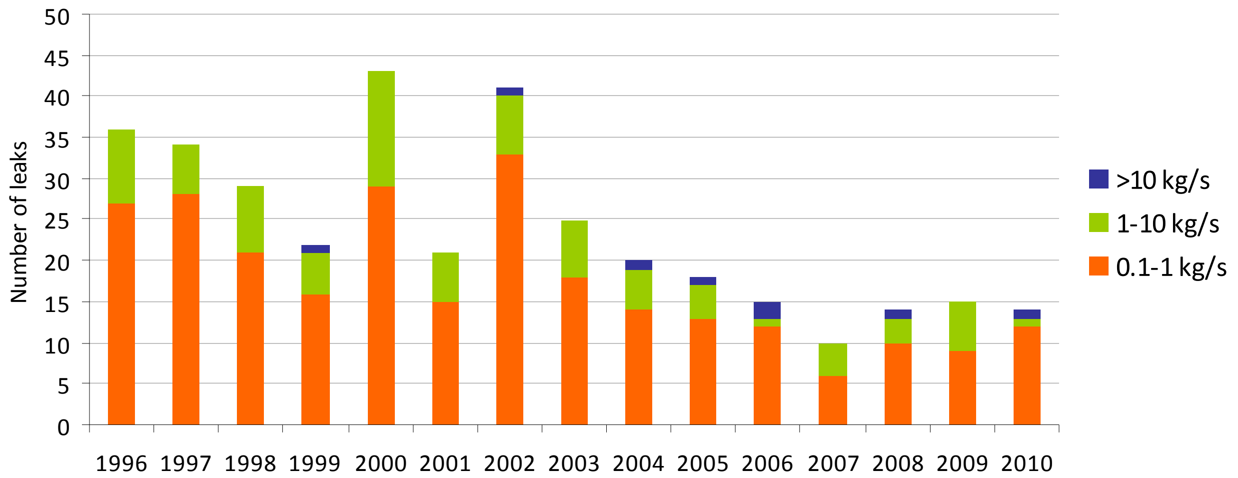


Figure 9 Number of hydrocarbon leaks exceeding 0.1 kg/s, 1996-2010

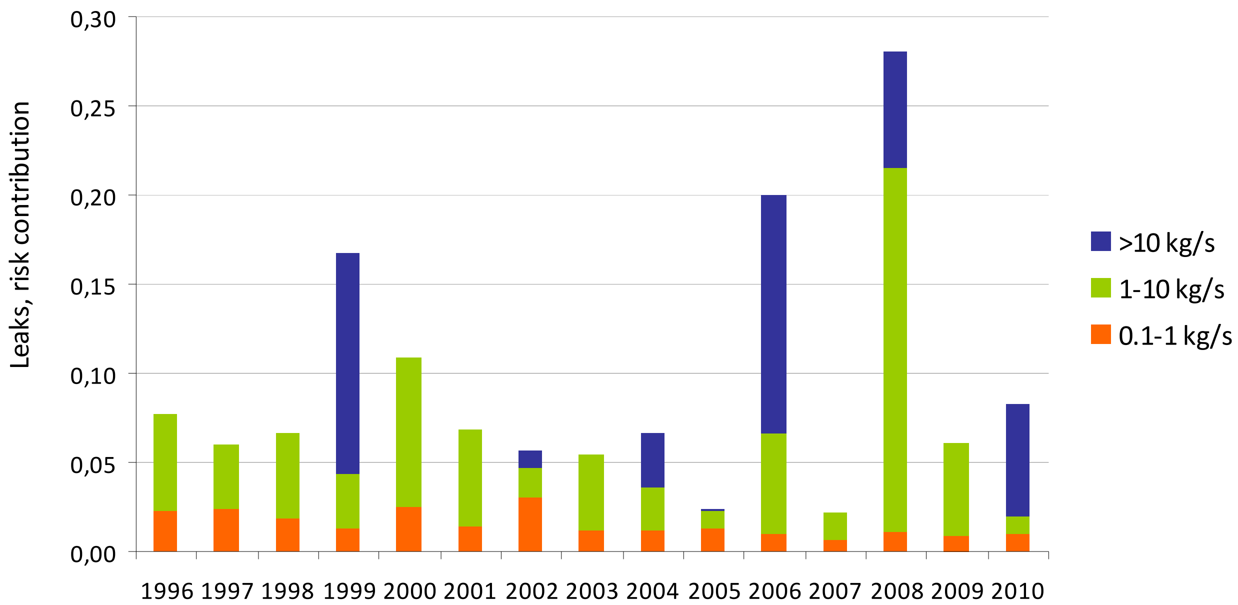


Figure 10 Number of hydrocarbon leaks exceeding 0.1 kg/s, 1996-2010, weighted by risk potential

Figure 10 shows the number of leaks when weighted in relation to the contribution to risk they are reckoned to give. In simplified terms, the contribution to risk from each leak is approximately proportional to the leak rate given in kg/s. Leaks exceeding 10 kg/s therefore make the biggest contribution even though there are no more than one or two such events a year. In most cases the weighting for these largest leaks is calculated manually from an assessment of the specific circumstances while the others are weighted following a formula. In 2010 both the leaks exceeding 1 kg/s were assessed specifically according to circumstances, the well control event on Gullfaks C in May 2010 and the collision between Far Grimshader and Songa Dee in January 2010, see Subsection 7.2.4.

Figure 11 shows the trend for leaks exceeding 0.1 kg/s, normalised against installation year, for all types of production installation. The figure illustrates the technique universally applied to analyse the statistical significance (robustness) of trends. Figure 11 shows that the there has been no statistically significant change in the reduction of the number of leaks per installation year in 2010 in relation to the average for the period 2005–09, despite a minor reduction from 2009. This is illustrated by the falling height of the column for 2010 in the middle hatched field of the column to the far right of the figure (”Int 05–09”, see also Subsection 2.3.5 in the Pilot Project Report). Leaks are discussed in the Main Report, normalised against both manhours and number of installations.

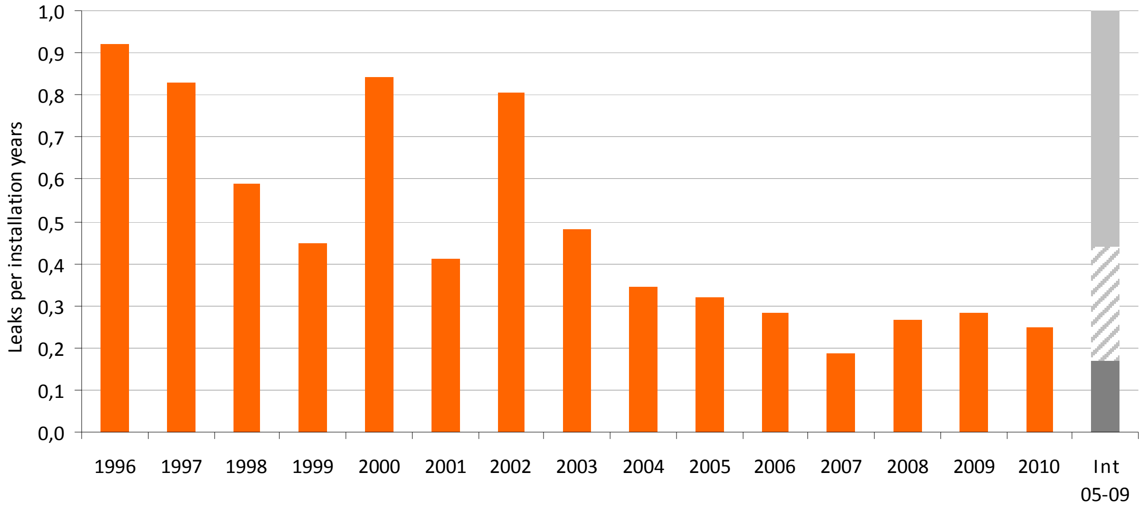


Figure 11 Trend, leaks, normalised against installation year, manned production installations

The frequency of leaks exceeding 0.1 kg/s shows considerable variation between operators. These differences have remained almost constant for many years, evidence that there is still clear potential for improvement. This is further substantiated by Figure 12, which shows the average leak frequency per installation year for operator companies on the Norwegian Continental Shelf. In previous years this figure has been presented for the entire period from 1996 to the present day. If the period is limited to the last five years, the same companies are seen in general to have the highest frequencies, but they are no longer much above some of the other companies.

A presentation of average leak frequency for each installation shows that the five installations with the highest average frequency in the period 2005–2010, all under the same operator, account in total for one-third of the number of leaks on the Norwegian Continental Shelf in this period. Four of the five installations with the highest average frequency were also among the top five in corresponding presentations in RNNP reports from and including 2005.

A systematic comparison has been made for gas, condensate and oil leaks on the UK and the Norwegian Continental Shelf in the areas north of Sleipner (59 °N), where the installations on both sectors are of generally corresponding scope and complexity. It should be noted that the reporting period of the UK Health and Safety Executive runs to 31.3. each year. The last period for which data are available is 1.4.2009–31.3.2010 (called ‘2009’), which is compared with the 2009 period on the Norwegian Continental Shelf).

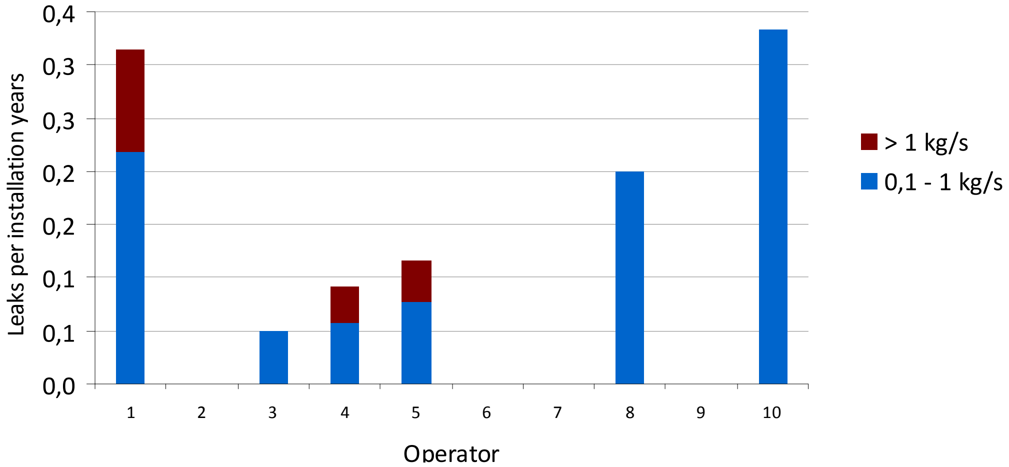


Figure 12 Average leak frequency, per installation year, 2006-10

Figure 13 shows a comparison between the Norwegian and UK Continental Shelf, in which gas/two-phase leaks and oil leaks are both included, normalised against installation year, for the two respective continental shelves north of 59°N. The figure applies to the period 2000-09. The data included in the figure are limited to process facilities in which oil leaks have occurred. In this period there was also one leak per year in shafts in connection with storage cells, on the northern sector of the UK Shelf, and one leak every third year in connection with tank operations on production ships or storage tankers. No corresponding leaks occurred in this period on Norwegian production installations but in 2008 there was a major oil and gas leak in the shaft on Statfjord A on the Norwegian Continental Shelf. These leaks are not included in the figure.

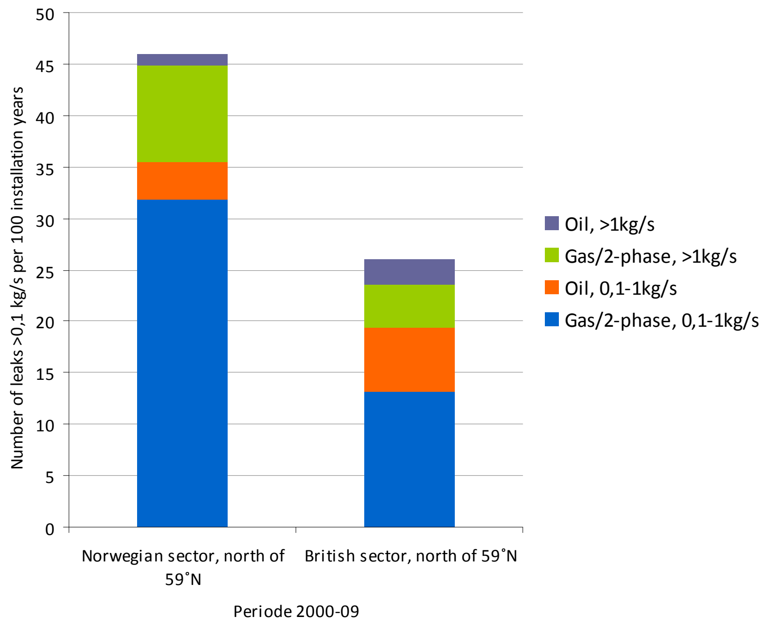


Figure 13 Comparison of gas/two-phase and oil leaks on the Norwegian and the UK Continental Shelf per 100 installation years, average 2000-09

The number of leaks on the Norwegian Continental Shelf has been considerably lower in recent years, so the period in question is of some significance. For example the following observations can be made from the data in regard to average leak frequency per installation year for all leaks exceeding 0.1 kg/s:

For the period 2000–09: The Norwegian Continental Shelf 76 % higher than the UK Continental Shelf
For the period 2006–09: The Norwegian Continental Shelf 30 % higher than the UK Continental Shelf

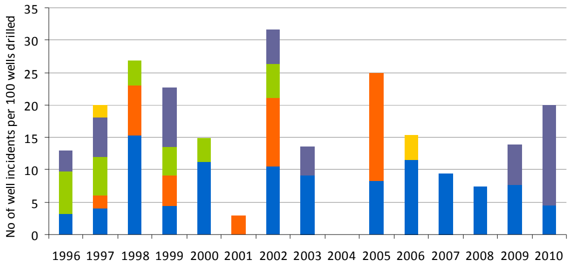
On the Norwegian Continental Shelf no occurrences of ignited hydrocarbon leaks (> 0.1 kg/s) have been registered since 1992. The number of hydrocarbon leaks > 0.1 kg/s since 1992 is probably in the region of 440. There is evidence that the number of ignited leaks is significantly lower than on the UK Continental Shelf, where approximately 1.5 % of gas and two-phase leaks since 1992 have been ignited.

7.2.2 Loss of well control, blowout potential and well integrity

Figure 14 shows the incidence of well incidents and shallow gas events distributed by exploration drilling and production drilling, normalised per 100 drilled wells. Exploration drilling and production drilling are shown collectively and with a common scale, for purposes of comparison.

For exploration drilling there have been large variations throughout the period, perhaps around a stable average on a par with the level in 1996. There was a substantial reduction in the period 2005–08, but frequency increased markedly in 2009 and 2010. Production drilling showed a rising trend up to 2003, with minor variations. In the period 2004 to 2008 there was a fall but frequency rose sharply in 2009 and 2010. With one exception all well incidents in 2009 fall into the category “regular” i.e. events with minor potential. There were also seven shallow gas events in 2010, a record high figure for events registered since 1996, all during exploration drilling.

Exploration drilling



Production drilling

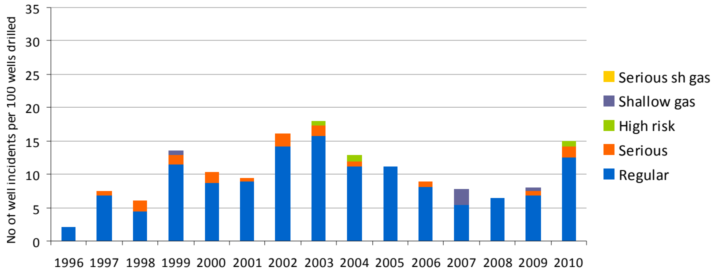


Figure 14 Well incidents according to degree of severity per 100 wells drilled, for exploration and production drilling

Figure 15 shows an overview of all well control events (for exploration and production wells) in relation to the areas on the Norwegian Continental Shelf in which well control events have occurred. The area classification corresponds to that given in the Norwegian Petroleum Directorate’s map of the continental shelf. There were previously many well control events in the Ekofisk area, but in 2009 and 2010 there has been a sharp rise in the number of well control events reported from the Norwegian Sea.

Well 34/10-C-06A, which was drilled from the Gullfaks C installation in the period November 2009 to July 2010, experienced several serious well control events. The last event, resulting in loss of well control, occurred on 19 May 2010. The Petroleum Safety Authority views this event as extremely serious. The event entailed enduring loss of a barrier and only chance prevented the event from developing into a major accident. The PSA’s conclusion is that the planning of the drilling and completion operation on this well contained serious and extensive deficiencies with respect to key factors such as risk and change management, experience transfer and competence, together with knowledge of, and compliance with, management documentation and decisions.

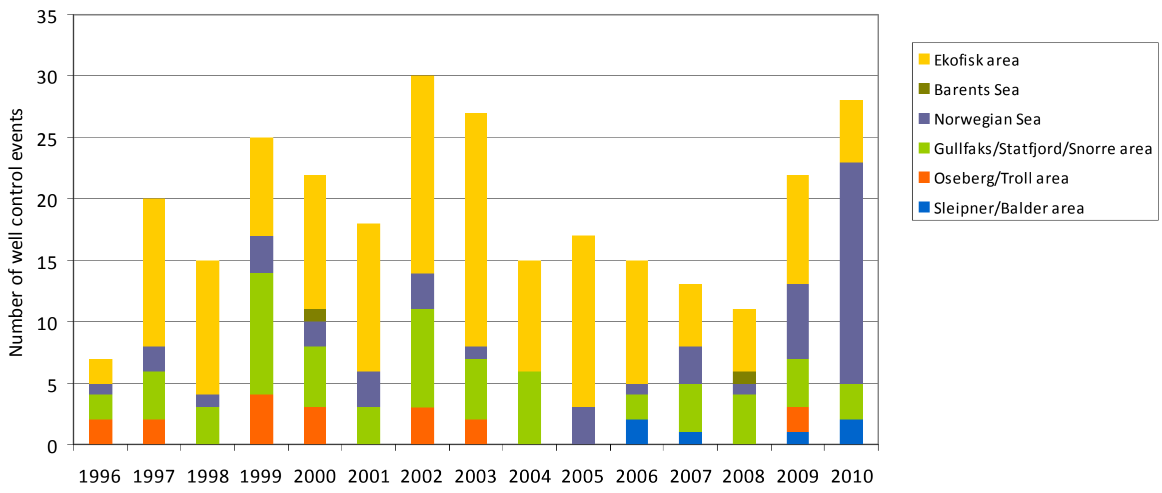


Figure 15 Distribution of well control events by area, 1996-2010

The Well Integrity Forum (WIF) established a pilot project in 2008 aimed at defining measurement parameters (KPI) for well integrity. Operator companies, ten in all, have reviewed all their "active" wells on the Norwegian Continental Shelf, a total of 1741 wells, with the exception of exploration wells and permanently plugged wells. Results were first reported in 2008 based on WIF's list of well categories, using existing definitions and subgroups per category. WIF has adopted the following system for well classification:

Red:	one barrier failed and the other degraded/unverified or with external leak
Orange:	one barrier failed and the other intact, or a single fault which may cause leaking into the external environment
Yellow:	one barrier leaking within acceptance criteria or the barrier is degraded, and the other is intact
Green:	intact well, with no or insignificant integrity factors.

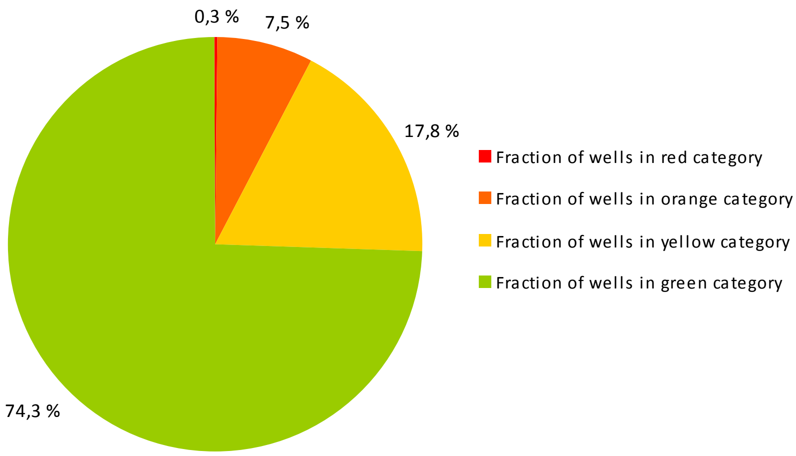


Figure 16 Well classification –category red, orange, yellow and green, 2010

The figure shows well categories by percentage of the total number of wells, 1741.

The results show that 7.9 % (8 % in 2009) of the wells have reduced quality in relation to the requirements for two barriers (red + orange category). 17.8 % (16 % in 2009) of the wells are in the yellow category. These are also wells with reduced quality in relation to the requirement for two barriers but the companies have implemented various compensatory measures to meet the two-barrier requirement. The remaining wells, i.e. 74 % (76% in 2009), fall into the green category. These are reckoned to have met the requirement for two barriers in full.

However, none of the reported conditions in category red or orange are of a nature requiring corrective measures beyond those already implemented by the companies themselves.

7.2.3 Leaks from / damage to risers, pipelines and subsea installations

In 2010 no cases were reported of leaks from risers or pipelines inside the safety zone of manned installations. This continues the trend from preceding years. In the last five years there has been an average of three serious cases of damage per year to risers and pipelines inside the safety zone In 2010 four cases were reported of serious damage to risers and pipelines in the safety zone, three of which were to a flexible riser on a mobile production unit and one on a rigid riser. This confirms trends in which the fault rate (the number of faults per operational year) is higher for flexible risers than for rigid risers.

Cases of serious damage are also included in calculation of the total indicator but with a lower weight than leaks. Figure 17 shows the most serious cases of damage in the period 1996-2010.

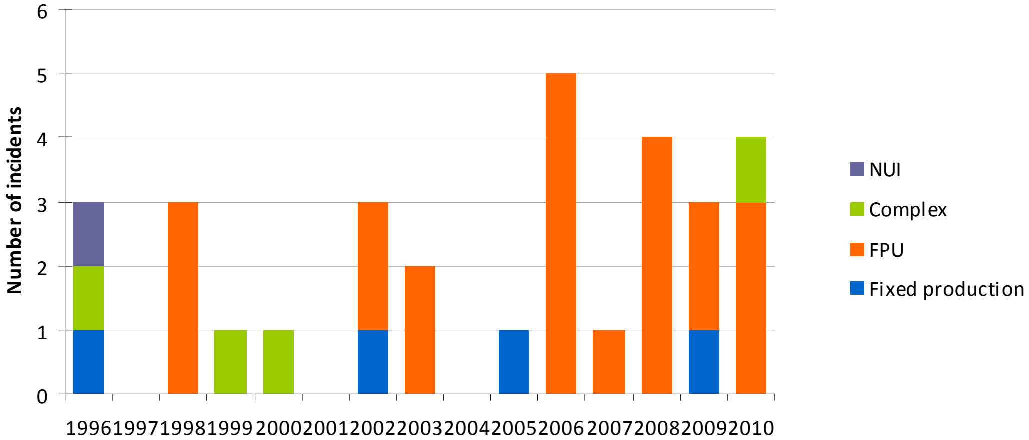


Figure 17 The number of cases of serious damage to risers and pipelines within the safety zone, 1996-2010

7.2.4 Vessel on collision course, structural damage

There are only a handful of production installations and a few more mobile units where the installation itself or the standby vessel is responsible for monitoring passing traffic where vessels are on a possible collision course. In all other cases monitoring is from the traffic centres at Ekofisk and Sandsli. It would be an improvement, especially for production installations, if all traffic was monitored from traffic centres, as all experience indicates that the quality of monitoring is better than that achievable by the individual installation or standby vessel.

For almost ten years there has been an indicator for DFU5 in which the number of vessels reported to be on possible collision course was normalised in relation to the number of installations monitored from the traffic centre at Sandsli, given as the total number of monitoring days for all installations monitored by Statoil Marin at Sandsli. The number of vessels registered as being on collision course has dropped substantially in recent years.

For collisions between vessels associated with petroleum activities and installations on the Norwegian Continental Shelf, a high level was observed in 1999 and 2000 (15 events per year). Statoil in particular has worked diligently to reduce the number of these events and in recent years the level has remained at about two to three a year.

The most serious collision in 2010 occurred between the supply ship Far Grimshader and the semi-submersible rig Songa Dee. Far Grimshader was working on the lee side of the Songa Dee. The crane on the rig malfunctioned and the supply ship had to be moved to the windward side to use another crane. During the move, the ship's propeller was caught in a wire attached to the rig's anchoring. The ship lost control and lay striking the Songa Dee for two hours. The Songa Dee sustained damage to two columns and was holed in one place. The hull of the Far Grimshader was breached in six places and there was holing on the main deck, with water penetration to the engine room. The collision force of each impact was low but there may have been as many as several hundred impacts.

A comparison of the size of vessels colliding with installations, as seen in Figure 18, shows that the average size of vessels has substantially increased, by approximately 100 tons a year since the 1980s. Collision force increases proportionately with the size of the vessel. This means that, given the same speed, the average vessel will cause more damage today than 20 years ago. In 2010 there were three events, giving a substantially smaller statistical basis for 2010 than for the other curves.

Current rules and regulations require flotels and production installations to withstand the loss of two anchor lines without serious consequences. The loss of more than one anchor line occurs from time to time, with potentially large consequences but seldom as large as on Ocean Vanguard in 2004. Mobile drilling units are only required to withstand the loss of one anchor line without unplanned consequences. In the last ten years there has been in the order of two events on average per year, with the exception of 2006, when there were six events of this kind. In 2009 and 2010 there were respectively one and zero such events, the lowest incidence since 2000.

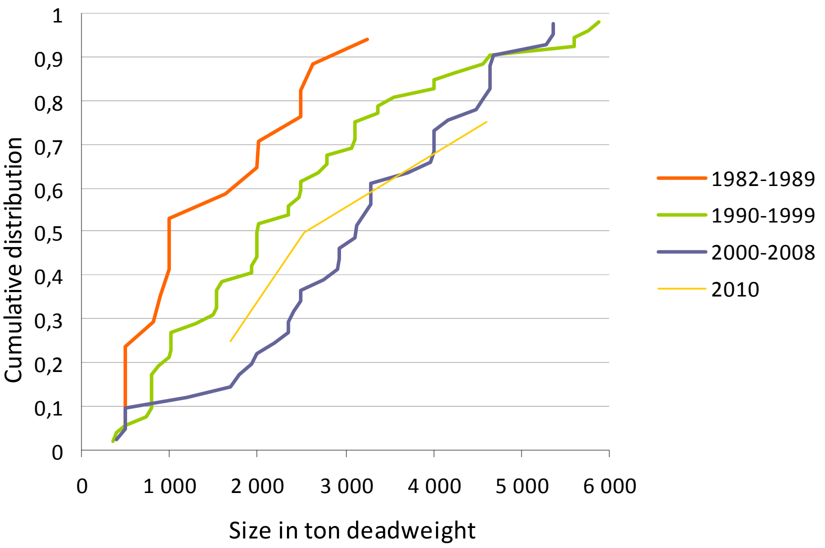


Figure 18 Cumulative distribution of size of vessels (excluding tankers) in DWT involved in collisions, 1982–2010

Structural damage and events included in RNNP are mainly classified as fatigue damage but some cases relate to storm damage. With respect to cracks, only penetrating cracks through the entire thickness of the structure are taken into account. In the wake of the Alexander Kielland catastrophe, structural cracks are taken very seriously in Norway. Cracks are generally the result of errors in design, choice of materials and manufacture. However, some of the installations have been in use for a longer period of time than previously assumed in the analyses. Connections can be shown on mobile units between the degree of cracking and changes in displacement of mobile units since the facility was new. Many other factors play an undoubted role. There is no clear relation between the age of the installation and the number of cracks. Storm damage refers mainly to cases of damage to the deck area but there may also be cracking on the hull. In 2010 three events involving extensive cracks in the hull were reported. The incidences of damage are relatively constant with one to three cases of serious damage a year, with no special trend.

7.3 Total indicator for major accidents

The total indicator applies to major accident risk on installations, while risk associated with helicopter transport was discussed in Section 6. The model gives DFUs a weighting based on the probability of fatalities. We wish to emphasise that this indicator is only a supplement to the individual indicators and is an expression of trends in risk level relating to major accidents.

The total indicator weights contributions from observations of the individual DFUs in relation to their potential for loss of life (see the Pilot Project Report), and will therefore vary to a substantial degree from observations of the individual DFUs. Figure 19 shows the indicator with yearly values and 3-year rolling averages. The large jumps from year to year disappear when 3-year rolling averages are considered, making the longterm trend clearer. Manhours are used as a common parameter for normalisation against activity level. The normalised value level is put at 100 in year 2000.

The main impression is that of a relatively stable level up to 2006, while from 2007 there is a reduction and a fairly constant lower level. Individual events with substantial risk potential can result in greater variation and have an effect over 3 years because of averaging, as the figure clearly shows for 2004 (Snorre A blowout). In 2010 it was the well event on Gullfaks C on 19 May (see Subsection 7.2.2) which had the highest value, based on the potential of the event. Two other leaks and the collision between the supply ship Far Grimshader and the mobile unit Songa are the other DFU events which have been given higher values based on the potential in these events, although not as high as the Gullfaks C event.

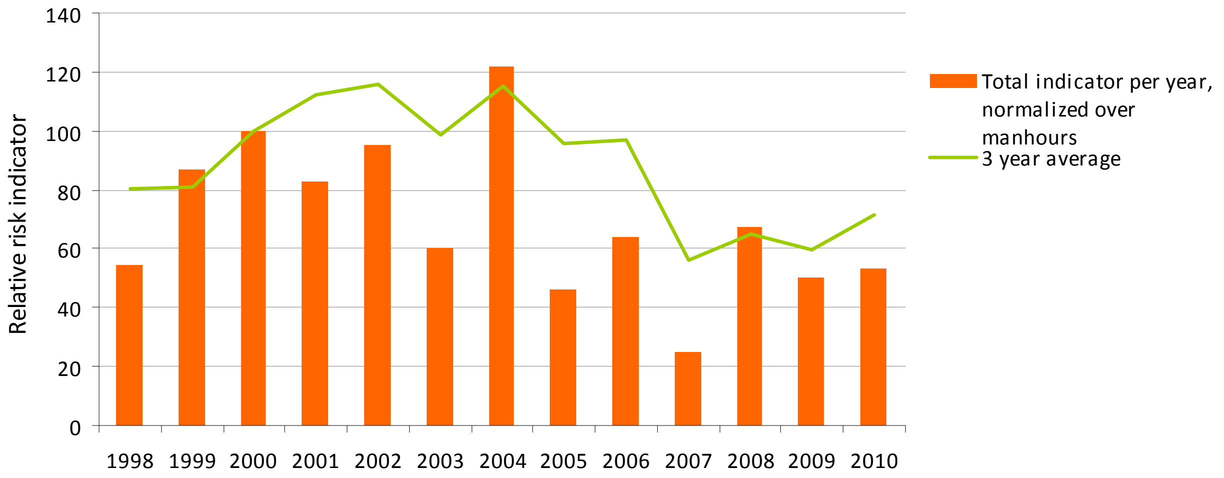


Figure 19 Total indicator, production installations, normalised against manhours, yearly values and 3-year rolling averages

Figure 20 shows the trend of the total indicator for mobile units, with yearly values and 3-year rolling averages. The values in 2009 and 2010 are the lowest 3-year averaged values for the entire period; in 2010 the collision between Far Grimshader and Songa Dee and a number of well events make the most telling contributions to the increase in yearly value. There is an overall falling trend throughout this period, taking the 3-year average into account.

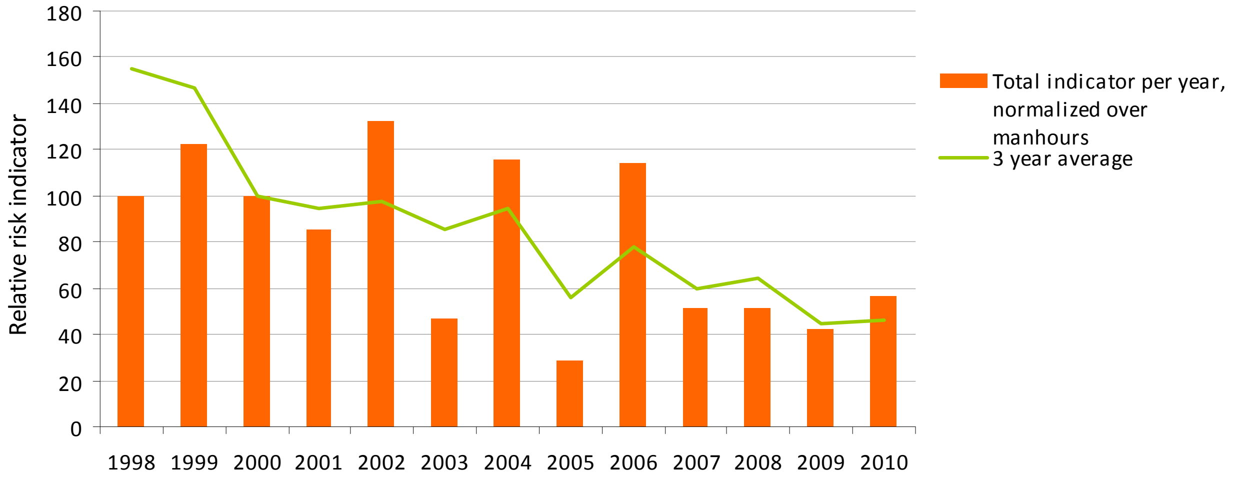


Figure 20 Total indicator, mobile units, normalised against manhours, yearly values and 3-year rolling averages

8. Status and trends—barriers against major accidents

The reporting and analysis of barrier data have been continued, with no significant changes from preceding years, only minor modifications and additions. As before, companies report test data from periodic testing of selected barrier elements.

8.1 Barriers in production and process facilities

The main focus is on barriers relating to leaks in production and process facilities, where the following barrier functions are included:

- maintain the integrity of hydrocarbon production and process facilities (covered to a large extent by the DFUs)
- prevent ignition
- reduce cloud/spill
- prevent escalation
- prevent fatalities.

The different barriers comprise a number of coordinated barrier systems (or elements). For example, a leak must be detected before any isolation of ignition sources and emergency shutdown routines (NAS/ESD) are effectuated.

Figure 21 shows the relative fraction of failures for those barrier elements relating to production and process, for which test data have been acquired. These test data are based on reports from all production operators on the Norwegian Continental Shelf.

The fraction of failures is generally on a par with the industry's availability requirements for new installations, but the highest values in the figure are above this level. Overall there is no uniform picture, the most characteristic feature being a stable level with minor variations. Those installations with a low fraction of drills meeting efficiency requirements continue to feature from year to year.

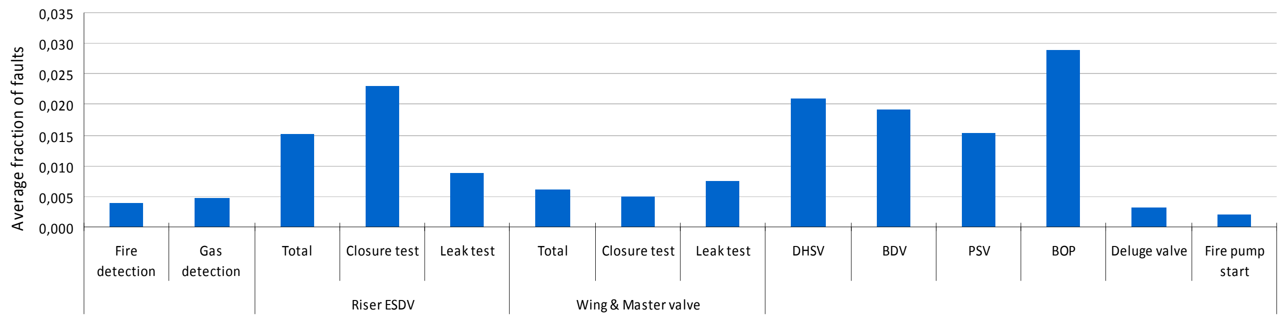


Figure 21 Mean fraction of failures for selected barrier elements, 2010

The two barrier elements showing a negative trend in 2010 are ESDV and BOP on risers, where fewer tests have been reported and where there is a higher fraction of failures. A request for more detailed BOP data has resulted in extensive non-reporting for BOPs when these are not owned by the companies themselves. Data for ESDVs are discussed in connection with Figure 23.

The Main Report shows the difference between the mean fraction of failures (Figure 21), i.e. the fraction of failures for each installation separately and then the mean for all installations, and the "total fraction of failures", i.e. the sum of all failures on all installations reporting data divided by the sum of all tests for all installations reporting data. The mean fraction of failures gives all installations the same contribution to the average, regardless of whether they have many tests or few.

Installations which have consistently shown many failures in testing of multiple barrier elements have been analysed to enable comparison with the number of leaks exceeding 0.1 kg/s on the same facilities. A corresponding analysis has been performed for successive years, and the results remain consistent over this time. One of the installations in the "top 5" list for leak frequency (see Subsection 7.2.1) is also on the "top 5" list for a high fracture of failures of barrier elements.

Figure 22 shows the total fraction of failures per barrier element for the ten operators reporting test data in 2010. The figure shows that there is substantial variation in the fraction of failures per barrier element between the different operators. The variation noted is due to different factors, which are discussed in the Main Report:

- *Difference in test interval*. The total fraction of failures is calculated as X/N where X is the number of failures and N the number of tests. If the failure rate, i.e. the number of failures per time unit, is assumed to be constant, it is reasonable to assume that the proportion of total fraction of failures will diminish if test frequency increases. Differences in test interval have been observed, although the impact of this has not been analysed in detail.
- *Difference in the number of installations for which operators are responsible.* Fewer installations and components result in greater variation.
- *Differences in the test pressure companies use.* Some companies apply lower pressure for the testing of PSVs than others, resulting in more failures.
- *Difference in the number of tests.* Variation is normally largest in the case of barrier elements with relatively few tests.

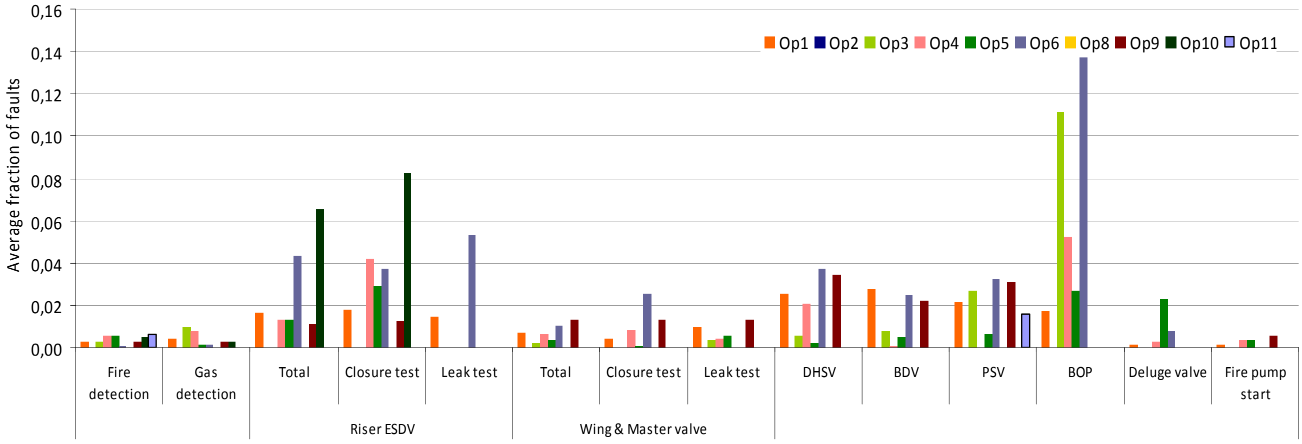


Figure 22 1–10 **Total fraction of failures presented per barrier element for operators**

The failure criteria for ESDV (generally the acceptable internal leak rate) can vary between installations and between companies, since criteria are determined on the basis of risk calculation. Acceptable internal leak rate for wellhead wing and master valves is given by API and is thus common for all installations and companies.

Figure 22 shows average values for each of the operator companies and large variations are evident for several of the barrier elements. Even greater variations can be seen if we look at the individual installations, as has been done for all barrier elements in the Main Report. Figure 23 shows an example of this comparison for testing of emergency shutdown valves (ESDV) on risers and flowlines. Each installation has a letter code and the figure shows the fraction of failures in 2010, the average fraction of failures in the period 2002–10 and the total number of tests performed in 2010 (as text on the X-axis, together with the installation code). Most installations have an average of below 0.03, but there are many installations with a higher fraction of failures, some close to 0.10. Two installations had a high number of failures in 2010, with more than 10 % failures in the number of tests. The figure covers both tests of the time taken for the valve to close (closing test) and tests of whether the valve remains sealed or has minimal leaking below the defined limit for acceptable internal leaking (leaking test). Fewer tests were reported in 2010, owing mainly to previous over-reporting by some installations because of unclear interpretation of reporting requirements. The average fraction of failures for all installations is 2.2% in 2010, while the average for all installations over the period 2002–2010 is 1.65 %.

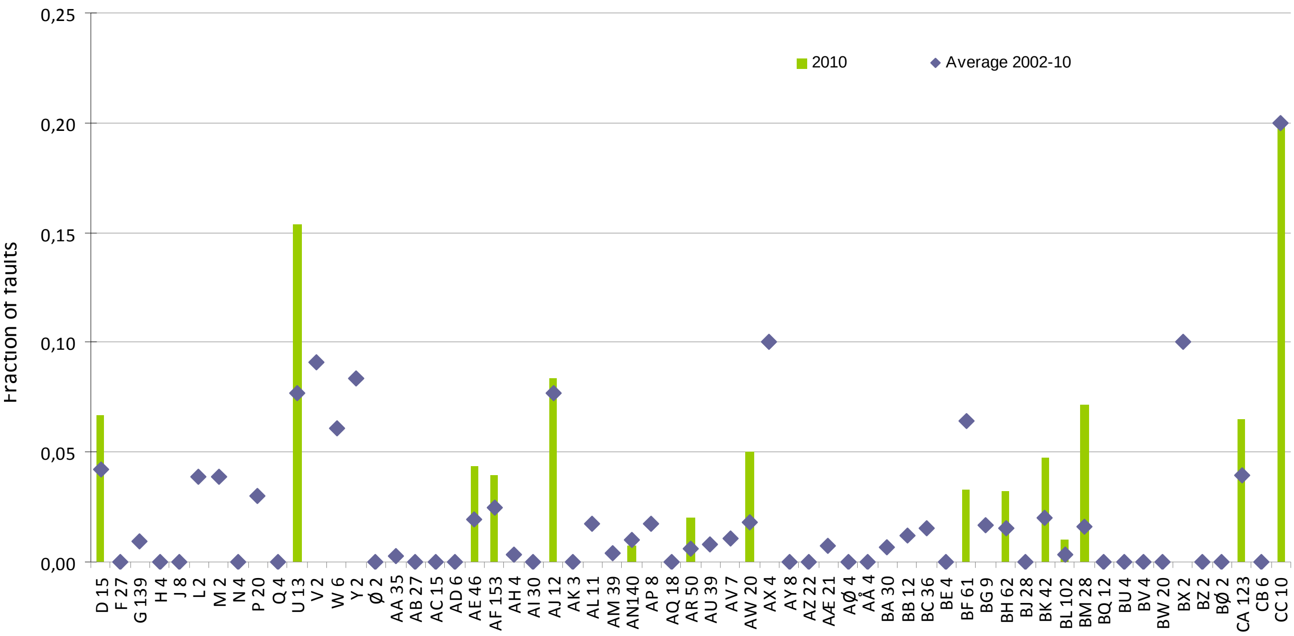


Figure 23 Fraction of failures for closing tests of wing and master valves

8.2 Barriers relating to marine systems

In 2010 there was data acquisition for barrier elements relating to marine systems, for:

- Watertight doors
- Ballast system valves
- Time without acceptable signals from three reference systems or fewer than two reference systems following different principles (applies only to mobile units)
- Metacentre height for mobile units.

Data were collected for both floating production units and mobile units. With respect to production units, the fraction of failures in 2006 in relation to tests of watertight doors and ballast system valves corresponded to 1.5–2 % while the values for ballast valves after 2006 have lain around 0.5 %, with the exception of 2009 when values were at 1%. The fraction of failures of watertight doors for production installations after 2006 has lain around 0.2 %. For mobile units number of tests and number of failures vary from unit to unit. Average values are partly lower than for floating production units with respect to tests of watertight doors and ballast system valves.

A new element in 2010 is that there has been a request for data on metacentre height (GM) for floating production installations, while no such data have been requested for mobile units since 2008. GM refers to the distance from the metacentre (M) to the centre of gravity (G) on the installation. A high positive value indicates good intact stability. The installation is stable when the metacentre height is positive and unstable with negative values. This value will generally indicate weight changes on the installations but will also show if there are changes in buoyancy volumes. The average metacentre height on 31.12.2010 was 2.9m for mobile units and 3.3m for floating production installations. The minimum requirement stipulated in the Maritime Directorate's stability regulations for semisubmersibles is 1.0m for all operational conditions, and all the installations satisfy this requirement. The average metacentre height has fallen by 15% in the period 2008 to 2010, while the minimum metacentre height has increased by 7% in the same period.

8.3 Indicators for maintenance management

In 2006 PSA launched the project *Maintenance as a means of preventing major accidents: maintenance status and associated challenges.* One of the project's aims was to update the status of maintenance management in petroleum activities with a view to determining the importance of maintenance in the prevention of major accidents. The project showed that classification of systems and equipment had not improved in relation to the status indicated in Storting White Paper No. 7 (2001-2002). Audits conducted by PSA in the period 2006–2009 revealed a number of non-conformities in all companies audited. The most recurrent non-conformities are:

- deficient classification of systems and equipment,
- inadequate use of classification,
- inadequate overview of outstanding maintenance,
- lacking/deficient documentation,
- lacking/deficient competence
- deficient evaluation of maintenance efficiency.

As a result of these findings, indicators for maintenance management were introduced in 2009, both for production installations and mobile units on the Norwegian Continental Shelf. Our particular area of focus is *the decision basis for maintenance management,* i.e. tagging of systems and equipment on the installations, classification of the tagged elements and how much of the classified material is critical in relation to health, safety and the environment ("HES-critical"). Also included is *the status of maintenance already performed*, i.e. the hours spent on preventive and corrective maintenance, backlogs in preventive maintenance and out-standing corrective maintenance, also with a view to HES-critical systems and equipment. The reporting categories in the introductory phase are the following:

Decision basis for maintenance management:
- The total number of tagged equipment items
- The number of classified tags
- The number of tags classified as HES critical

Status of performed maintenance:
- Preventive maintenance backlog, number of hours in total
- Preventive maintenance backlog, number of hours, HES critical
- Corrective maintenance outstanding, number of hours in total
- Corrective maintenance outstanding, number of hours, HES critical

The Main Report shows all indicators; only two are shown here. Figure 24 shows a substantial backlog of preventive maintenance for production installations, while Figure 25 shows a substantial backlog for mobile units.

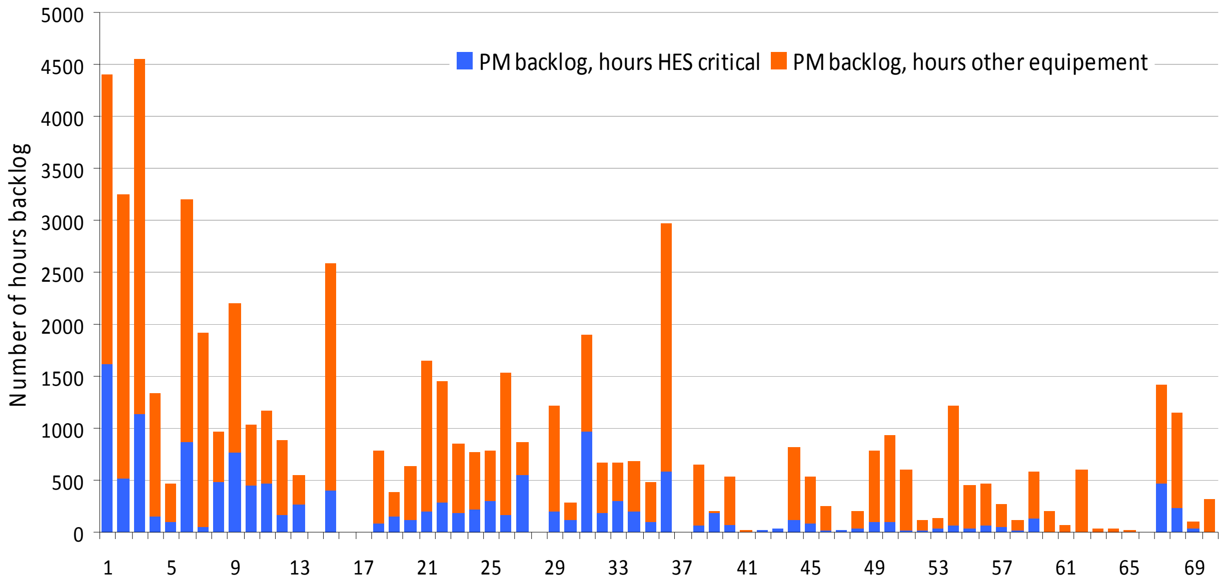


Figure 24 Overview of preventive maintenance, production installations

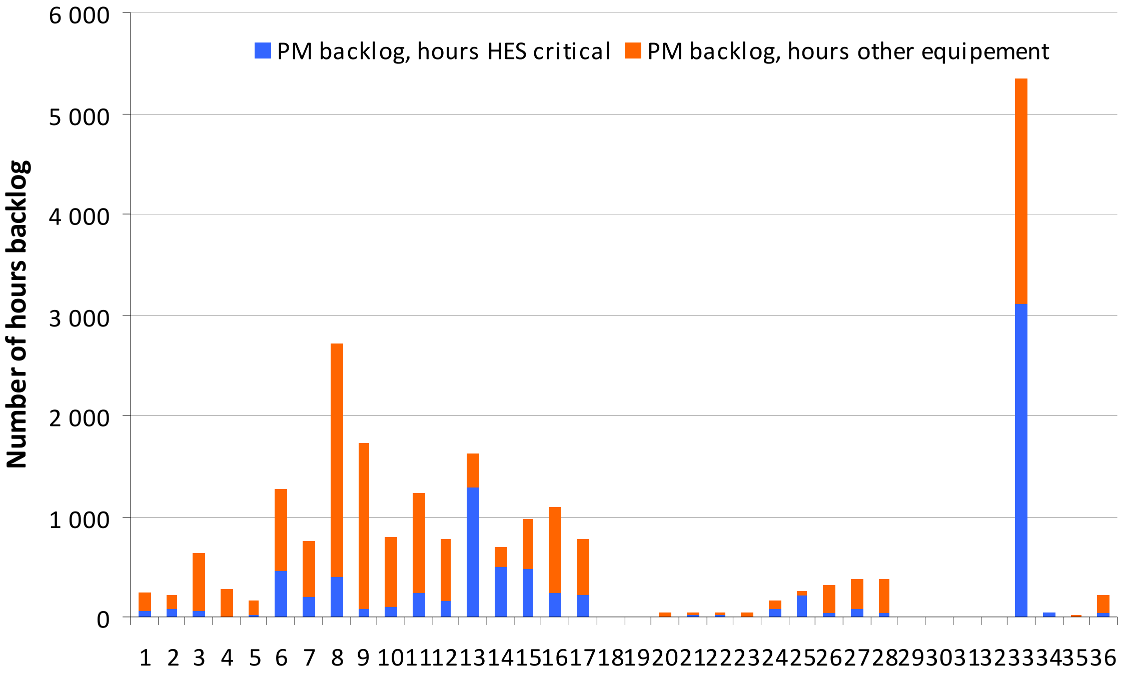


Figure 25 Overview of preventive maintenance, mobile units

There is therefore a considerable list of planned maintenance work waiting to be performed, including work on HES-critical systems and equipment. Maintenance backlogs introduce factors that contribute to risk. It is thus important that a strict check should be kept on this backlog and the risk it represents.

In regard to tagging and classification of equipment, the figures for 2010 show that more production installations have tagged their systems and equipment than was the case in 2009. Mobile units continue to show low figures for tagging and classification. For certain installations the level of classification is so low that it can be difficult to establish a risk-based decision-making basis for maintenance purposes.

9. Status and trends – occupational accidents resulting in fatalities and serious injury

For 2010 PSA has registered 279 cases of injury to personnel on petroleum-related installations on the Norwegian Continental Shelf that come under the criteria of death, medical treatment or absence continuing over into the next shift. In 2009, 333 cases of injury were reported. There were no fatal accidents in 2010 within the PSA's area of authority on the Norwegian Continental Shelf. Reports were also received in 2010 of 54 cases classified as occurring during leisure-time (off-duty) activities and 103 cases of injury requiring first aid treatment. By comparison, in 2009 there were 67 cases of leisure-time injuries and 151 cases requiring first aid; these are not included in the figures and tables.

On production installations in the period 2000 to 2004 there was a clear and consistent fall from 26.4 to 11.3 cases of injury per million manhours. From 2004 to 2008 the total frequency of injuries has remained generally unchanged at around 11 cases of injury per million manhours. This positive trend has been maintained in 2010. A total of 210 cases of injury on production installations were reported in 2010.

On mobile units, as for production installations, there has been a positive trend over the last ten years: from 2000 frequency has fallen steadily from 33.7 to 11.1 in 2006. In 2007 there was an increase in frequency of injuries but from 2008 the trend has been positive. Frequency has been reduced by one case of injury per million manhours from 2009 to 2010 (from 6.7 to 5.7) and is more than halved in relation to the level in 2007. In 2010 there were 69 cases of injury on mobile units as against 86 in 2009.

9.1 Serious injuries, production installations

Figure 26 shows the frequency of serious injury to personnel on production installations per million manhours. There was a falling trend in frequency from 2000 to 2004, but an increase in 2005. Since 2006 there has been no clear trend, with frequency varying between 0.65 and 0.87 and being at 0.79 in 2010. In 2010 there was a decrease in the contractor personnel group but an increase among operator personnel.

There were 23 cases of serious injury to personnel on production installations in 2010. The number of manhours increased from 28.6 million to 29.0 million in 2010.

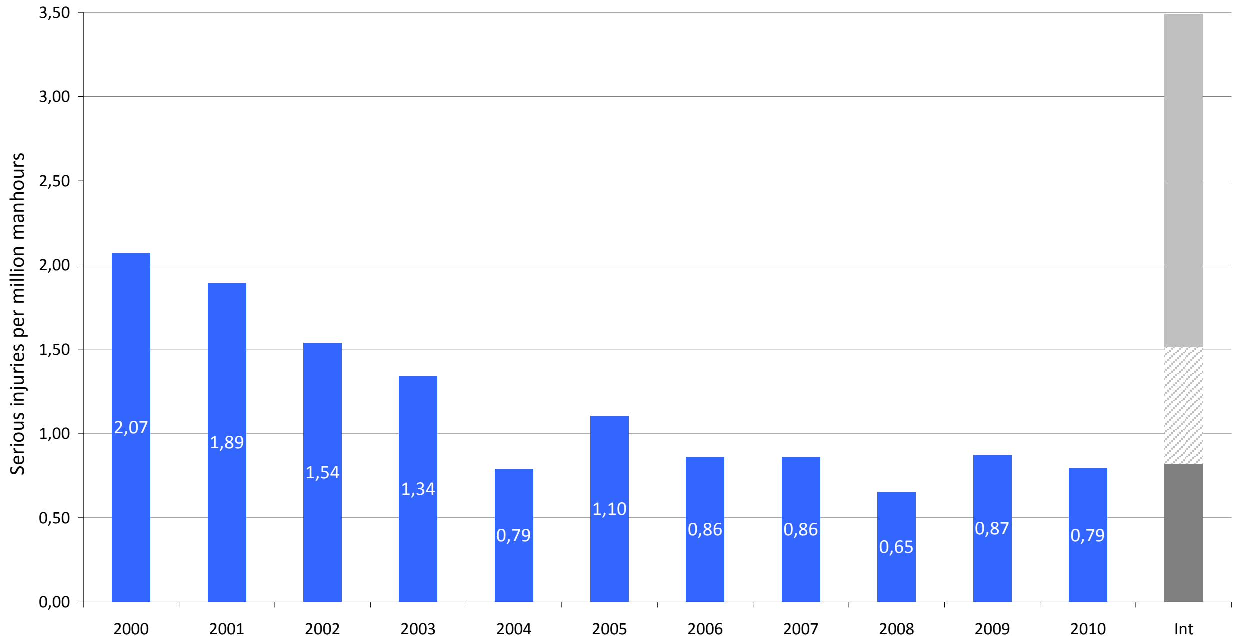


Figure 26 Serious injuries on production installations in relation to manhours

9.2 Serious injuries, mobile units

For 2010 the frequency of serious injury is 0.42 (see Figure 27), a continuation of a marked fall in recent years from a peak in 2000 and 2001. From 2002 to 2006 there were only slight changes in injury frequency. In 2008 we witnessed a renewed increase in frequency while in 2009 it was reduced to one-third of the level in 2008. This positive trend has continued, and in 2010 the frequency of serious injury is at the lowest level ever registered for mobile units. This frequency lies clearly below the value anticipated on the basis of the preceding 10 years.

9.3 Comparison of accident statistics between the UK and the Norwegian Continental Shelf

PSA and the UK Health and Safety Executive (HSE) produce a half-yearly joint report in which statistics of injuries to offshore personnel are compared. The classification criteria were basically almost identical, but a closer scrutiny revealed that there were nevertheless certain differences in classification practice. With a view to improving the basis for comparison, we have revised the system in dialogue with the UK authorities and agreed on joint criteria for the classification of serious injuries, so that the categories cover corresponding areas of activity.

The calculation of average injury frequency for fatalities and serious injuries for the period 2005 up to and including the first half of 2010 shows that there have been 0.85 cases of injury per million manhours on the Norwegian side and 1.01 on the UK Continental Shelf. The difference is not statistically significant. However, the difference in frequency of fatal accidents in the same period is larger. The average frequency of fatalities on the UK Continental Shelf is 1.37 per 100 million manhours as against 0.95 on the Norwegian Continental Shelf. This difference is also not significant. On the UK Continental Shelf there were four fatalities in the period as against two on the Norwegian Continental Shelf.

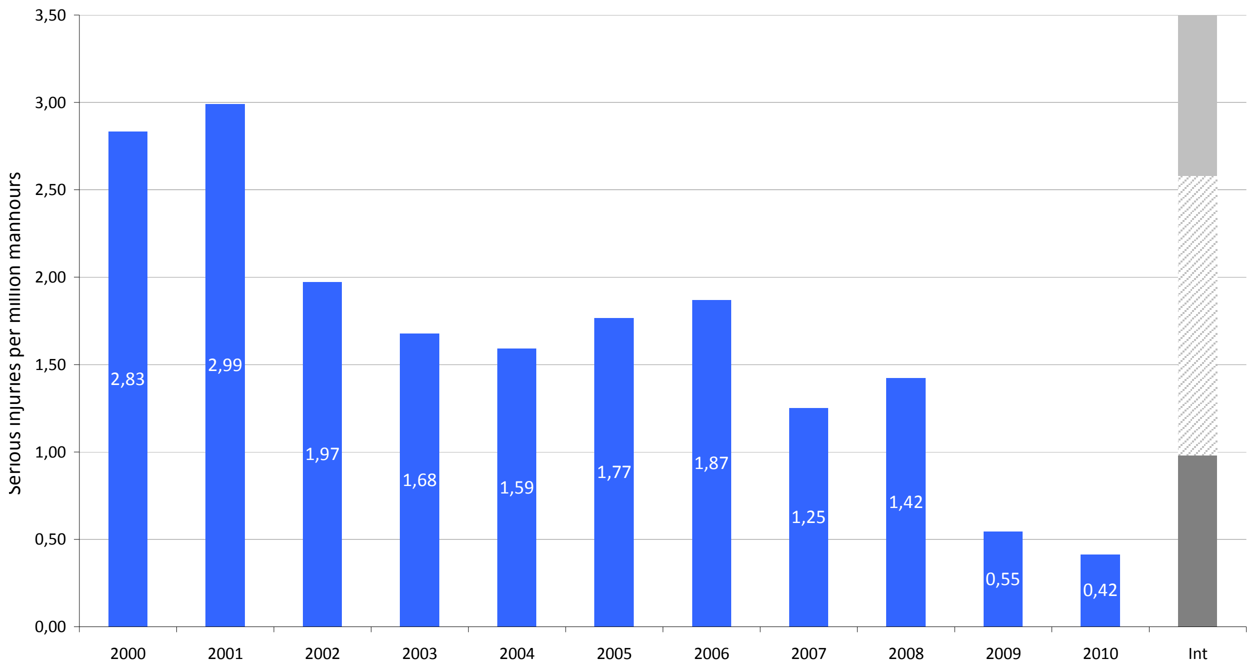


Figure 27 Serious injuries per million manhours, mobile units

10. Risk indicators – noise, chemical work environment and ergonomic factors

It has been stressed that indicators must express risk factors as early as possible in the causal chain leading to occupational injury or illness and that the indicators must lend themselves readily to use in companies' improvement work.

With few exceptions, data for noise and chemical work environment have been registered from all offshore installations and onshore facilities. In regard to noise, the data set shows that there is common understanding of reporting criteria and the indicator seems to give a realistic and consistent picture of the actual conditions. It also appears to be sensitive to change. Indicators for chemical work environment have been slightly modified to give better robustness, but there have been only marginal changes in 2010 in relation to 2009.

Indicators for ergonomic factors have been reported for the second time. The indicator has been changed from that in 2009 in which companies reported data for two work tasks they themselves assessed as giving a high risk of muscular/skeletal complaints. The new feature this year is that companies report data for a total of 80 % of the work tasks for each of the relevant personnel categories. This means that the indicators showing risk factors distributed by personnel category will give a more correct picture of the total load for each group. This modification means that data from 2009 and 2010 are not comparable.

Response from the companies has been generally positive. The work has created commitment and management interest in the topic of indicators, and the preconditions for prioritised risk reduction have improved. An important aim in the establishment of indicators is that they should support good processes in the companies. There is a high level of activity in the branch directed towards the development and implementation of methods and tools for risk assessment and management in regard to work environment factors, and there are several good examples of major improvement projects in the industry.

Indicators are based on a standardised data set and reflect only some aspects of a complex risk picture. Indicators cannot therefore be used as a substitute for companies' obligations to perform vulnerability and risk assessments as a platform for implementing risk-reducing measures.

10.1 Noise exposure harmful to hearing

Data have been reported from 71 facilities, 44 production installations and 27 mobile units. The production installations include 17 “new” and 27 “older” facilities. New installations are those with an approved plan for development and operation (PDO) after 1.8.1995. At that point of time, more stringent and detailed requirements relating to noise exposure were introduced (the SAM regulations).

The noise exposure indicator covers 11 pre-defined job categories. The total data reported represent 2259 offshore personnel.

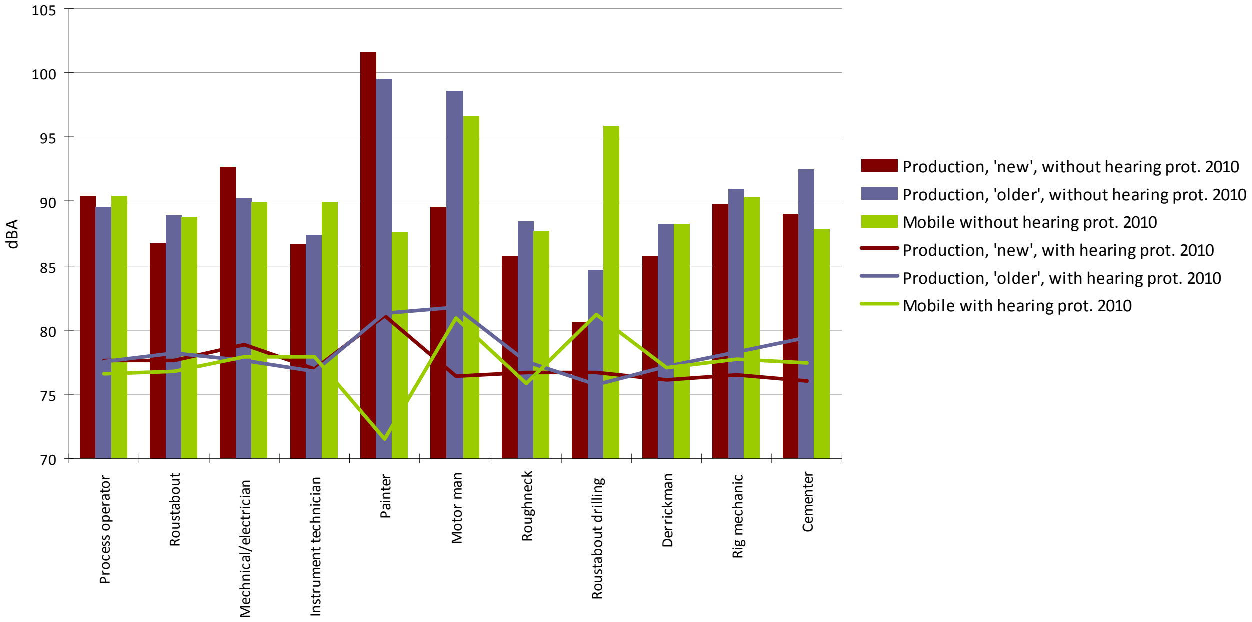


Figure 28 Average noise exposure by job category and installation type, 2010

The average noise indicator for the 2259 persons covered by the survey is 90.2. This is a slight reduction from the 2009 level of 90.7. An improvement was registered on 22 of total 71 installations, a slightly poorer result than in 2009. Only 5 installations report that no detailed risk assessment has been made for certain job categories. There has been a markedly positive trend here since the indicator was first established. In the majority of cases there is very little discrepancy between the noise indicator and the results from detailed risk assessments, which is a valuable verification of the indicator’s strength.

The noise indicator for the job categories machinist and surface treatment worker (painter) is markedly higher than for other groups and for these groups the noise indicator, including hearing protection, is also relatively high.

For most job categories, the noise indicator is lower on ”new” installations than on ”older” ones. Taking the picture as a whole, the trend has been positive for older installations but not for new installations, so that the risk level now appears to be the same. For mobile units, five of 11 job categories have lower noise exposure compared with the situation on new and older fixed installations. Seven installations reported that technical measures have been implemented which in combination have led to a reduction in noise exposure by respectively 1 dB, five installations with a reduction of 3 dB, 11 installations with a reduction of 5 dB and one installation with a reduction of 8 dB for certain job categories, which is an improvement in relation to the results for 2009.

Reporting of data confirms that some companies have formalised and implemented schemes for exposure hour limitations: of 71 installations there are 11 which have not introduced schemes of this kind for some job categories. This applies particularly to mobile units. As in previous years, there is still potential for improvement in this area on mobile units. Although it may be difficult to verify if this kind of measure is effective, there are examples showing that they can work. Schemes of this nature may have operational drawbacks and may in themselves serve to hasten the implementation of technical measures.

Although indicators point to high levels of exposure, there are still a number of installations which have not established plans for risk-reducing measures, see Figure 29. The picture shows a more positive trend than in 2009, particularly with reference to new production installations. For older production installations the picture has changed little in relation to that in preceding years. For mobile units approximately 90 % have established plans for risk-reducing measures. An improvement has been registered in terms of implementing measures in line with plans, for all installations. More cases of new and exacerbated hearing damage have been registered in the period 2010 for new and older production installations. Mobile units show a reduction in cases of new or exacerbated hearing damage compared to 2009.

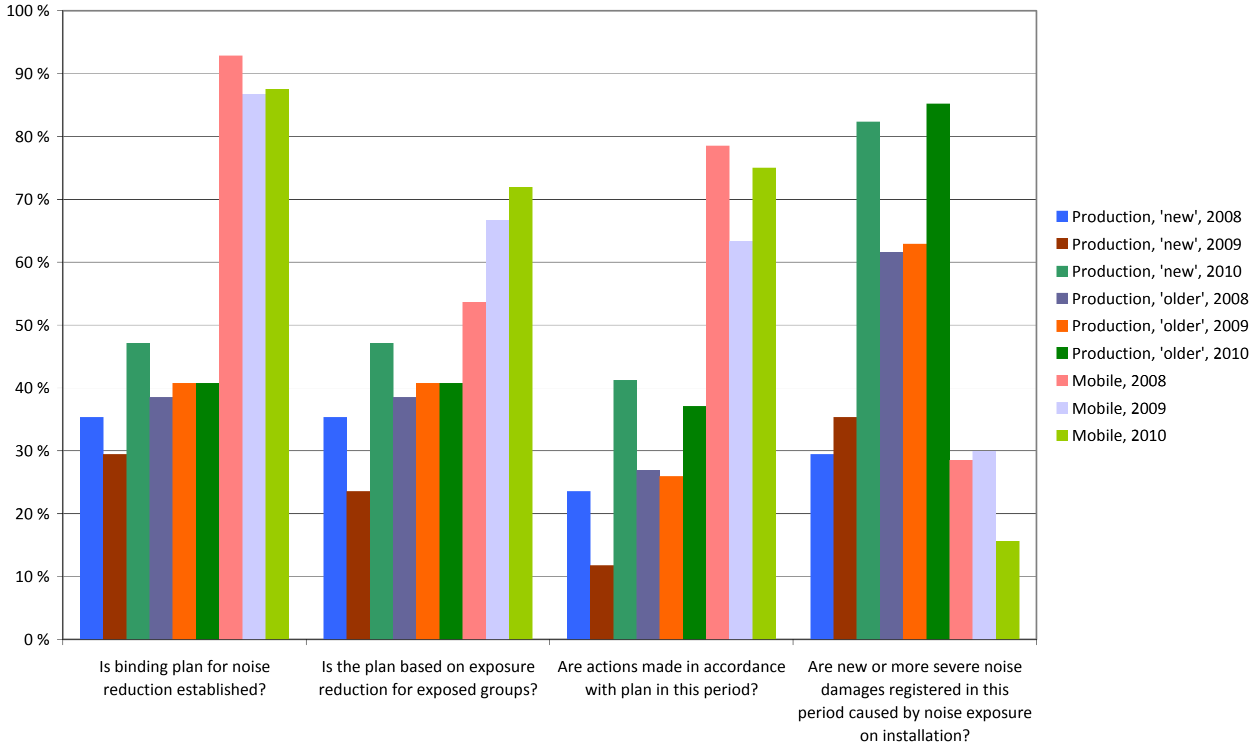


Figure 29 Plans for risk-reducing measures

If the noise indicator is assumed to reflect real exposure to noise, most job categories covered by this survey have a level of noise exposure exceeding 83 dBA, the maximum level stipulated in the Activities Regulations, Section 38. However, if we take into account the use of hearing protection as reported by the companies, we see that most job categories have a level of noise exposure within the stipulated limits. Even allowing for a conservative calculation of the dampening effect of hearing protection, this does not mean that the situation is satisfactory. Hearing protection has clear limitations as a preventive measure.

The indicator also calculates uncertainty in the result and the 95 % percentile for indicator values which typically lies 6–8 dB higher/lower than the average values shown in the figures. This means that a relatively high number of employees may have a much higher level of noise exposure than the average figures suggest. If we also take into account the evident uncertainty in regard to the effect of hearing protection and a consistently high level of reporting of hearing damage, a serious picture of risk level presents itself.

For 2010, 605 cases of noise-related injury were reported to the Petroleum Safety Authority as against 397 in 2009. This increase is due primarily to increased reporting for contractor personnel. Taking the picture as a whole, it seems clear that large groups of employees working in the offshore petroleum industry are exposed to high levels of noise and that the risk of developing noise-related hearing impairments is not inconsiderable. The PSA’s experience through its contacts with the industry, case-handling and audits indicates that the potential for noise-reducing measures remains large. Both the noise indicator and trends in hearing damage reports suggest that a special effort must be directed towards personnel categories in whose work handheld tools make a substantial contribution to noise exposure.

10.2 Chemical work environment

The indicator for chemical work environment has two elements. One is the number of chemicals in use listed by categories of health hazard, the hazard profile of the chemical spectrum and substitution data. The second element relates to actual exposure for defined job categories, which seeks to identify exposure carrying the highest risk. In addition, supplementary information has been reported on how companies manage the risk of chemical exposure. The establishment of binding plans and follow-up routines are key elements in this context.

The indicator for the chemical spectrum's hazard profile shows the number of chemicals in circulation per installation and chemicals with a high and defined hazard potential. This indicator has limitations in that it does not take into account how the chemicals are actually used and the risk this use represents. It nevertheless tells us something about companies' ability to limit the presence and use of potentially hazardous chemicals. It is a recognised scientific argument that the probability of health-hazardous exposure increases with the number of harmful chemicals in use.

The model involving the use of risk matrices to identify a direct indicator for chemical exposure has been applied as in 2009. For four defined job categories, the two cases with highest risk are reported, one based on a short-term assessment and the other on a full-shift assessment. The way in which data are reported does not take into account any risk reduction implied by the use of personal protective equipment.

The risk matrix with defined categories of health hazard and exposure is based on Norsok S-002 rev. 4 Annex G. Each cell in the matrix is assigned a risk value identical to the product of the numerical values (1-5) for health hazard category (inherent properties) and exposure category (1-6).

Data have been reported in 2010 from 40 production installations/fields and 32 mobile units. The reported data show that there is still substantial variation between companies in regard to the number of chemicals in use (Figure 30 and 31). For production installations and mobile units this reflects to some extent the type of installation and the activities on the installation.

The total number of chemicals for production installations and mobile units varies from 171 to 882. The arithmetic mean value is 472. For chemicals with a high hazard potential, the number varies from nine to 182. The arithmetic mean value is 75. Both for production installations and mobile units there is an increase in the number of chemicals in relation to preceding years.

628 cases in total have been reported of substitution with health benefits, for production installations and mobile units. This is an increase in relation to preceding years, when 205 cases were reported. The majority of these substitutions occurred on six of the 72 reported installations. Both production installations and mobile units show a marked rise in the number of substitutions in relation to 2009.

For production installations there are four which show an improvement in relation to 2009 in terms of the number of chemicals, while 35 installations show a deterioration. Drilling activities are excluded here. For mobile units, 23 show a deterioration in relation to 2009.

36 new cases of job-related skin complaints were registered in 2010, the majority of them the result of chemical exposure, as against 37 cases in 2009.

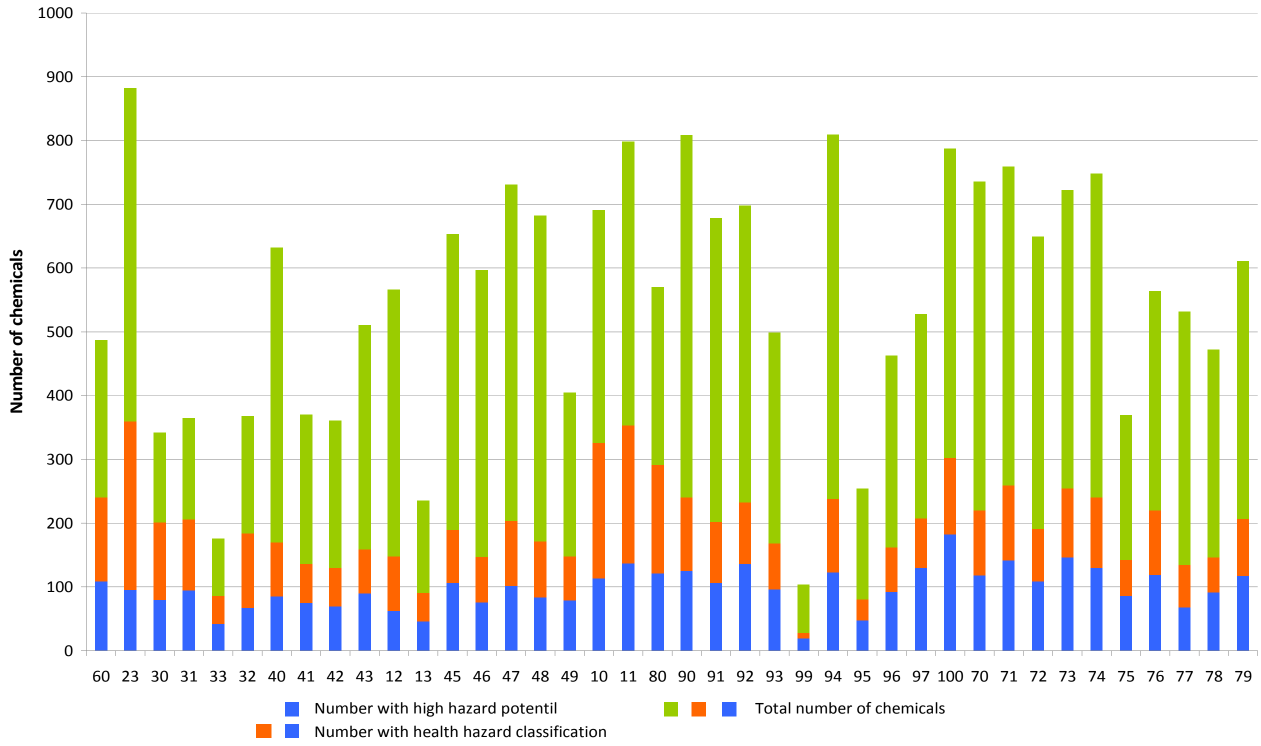


Figure 30 Indicator for the chemical spectrum's hazard profile – production installations

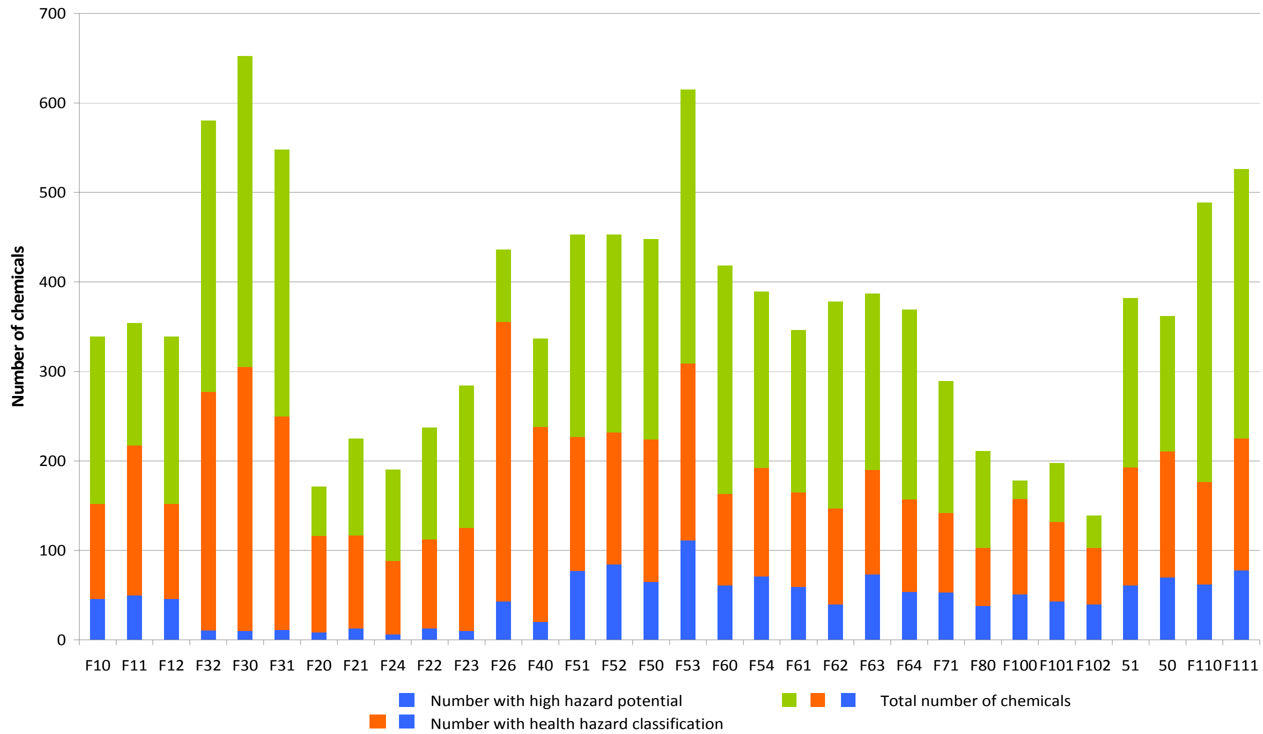


Figure 31 Indicator for the chemical spectrum's hazard profile - mobile units

10.3 Ergonomic factors

Indicators for ergonomic factors were reported in 2010 for the second time. The companies report data for a total of 80 % of work tasks for each of the relevant personnel categories. This helps the indicators showing risk factors from reported work tasks distributed by personnel group to give a more correct picture of the total load for each group. The six pre-defined job categories were selected by ergonomic specialists with experience from the industry.

The indicators were developed in cooperation with relevant disciplines in the companies and STAMI. In 2008 a status report entitled " Work as the cause of muscular/skeletal complaints" was prepared by STAMI at the behest of the Norwegian Labour Inspectorate and PSA. The results from this work were used in developing the indicators. The "Regulations relating to Heavy and Repetitive Work" and associated guidelines list the assessment criteria to be applied for reporting. The involvement of ergonomics experts in quality assurance of these assessments is a precondition emphasised by PSA.

Data have been reported from 22 production installations and 31 mobile units. In the *red* area the probability of incurring load injuries is very high. In the *yellow* area there is a certain risk of incurring load injuries in the short or long term. The load situation must be assessed more closely. Factors such as variation, tempo and frequency of loads are critical. A combination of loads can exacerbate the situation. In the *green* area there is little general risk of employees incurring load injuries. If there are any special factors, or if an employee nevertheless incurs load injuries, the situation should be assessed more specifically. The comment "high score" means that the task in question has been rated as red by many respondents.

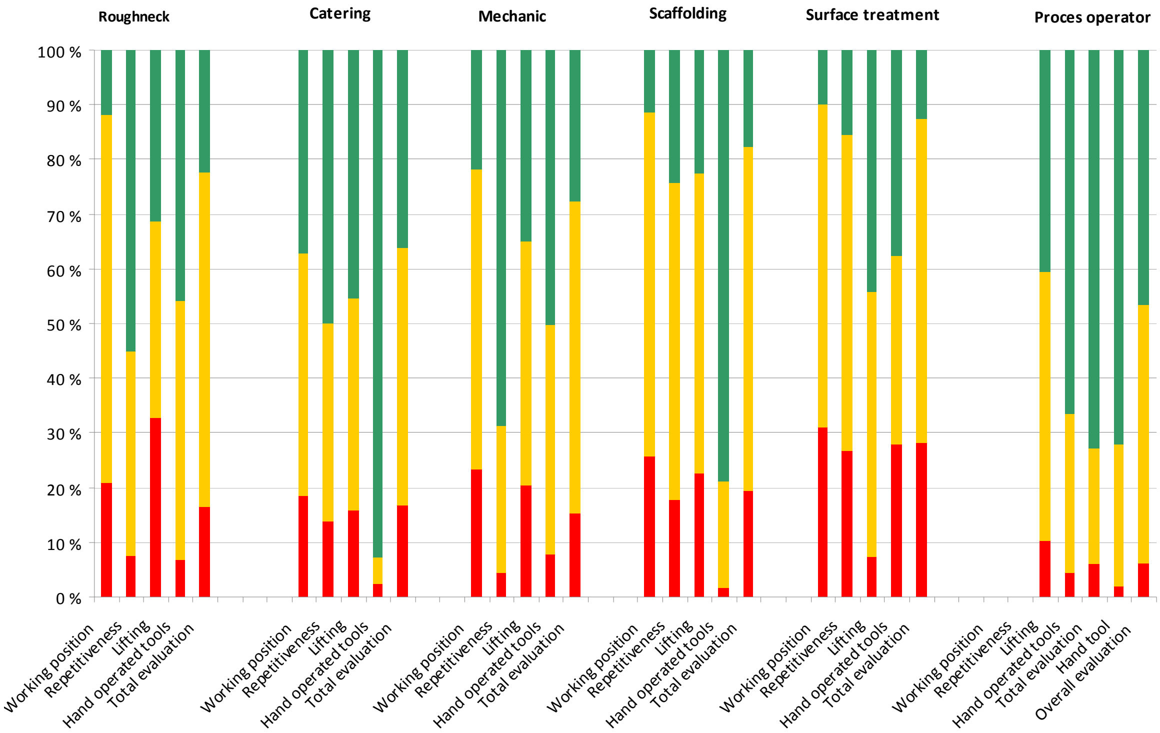


Figure 32 Risk factors from reported tasks, distributed by personnel category – production installations

The highest score on production installations (Figure 32) is reported for surface treatment workers (painters) in relation to working position, repetitive tasks and handheld tools. Only 12.7 % of work tasks here are assessed as "green", i.e. carry little risk for the development of muscular/skeletal disorders. Surface treatment workers are clearly distinguished in this context because of their high degree of repetitive work and use of handheld tools. Working with needle chippers is identified as a high-risk operation on several installations. We note from the report on land facilities that the risk score for onshore surface treatment workers is lower than that reported from offshore production installations. Drill deck workers also have a high overall score, particularly in connection with heavy lifts. Scaffolding workers have many difficult working positions and repetitive work, and few "green" tasks. Mechanics score highest on difficult working positions and heavy lifts. For catering personnel, working position, repetitive work and heavy lifts are noted as factors carrying high risk.

All three groups in Figure 33 report high scores for uncomfortable working positions.

Comparison of the results for production installations and mobile units in 2010: all three personnel categories on mobile units report substantially higher scores for working position.

For catering employees and mechanics this score is almost doubled on mobile units. For drill deck workers there is also almost a doubling of scores for repetitive work and more than a doubling for handheld tools. We have divided the results into newer and older production installations (with PDO earlier than 1995) in order to see if there is any difference in average risk score distributed by personnel category. This shows that risk is substantially higher for drill deck workers and catering employees in particular, but also for mechanics, on older production installations than on newer facilities. The division into older and newer production installations also shows that it is drill deck workers on older installations who have the highest average risk score.

In the results from the RNNP questionnaire survey (2009) for both production installations and mobile units, 83.5 % of surface treatment workers responded that they fairly often/frequently work in a hunkered-down or kneeling position, while 75.3 % report correspondingly for work above shoulder height. Additionally, 56.3 % of catering assistants and 46.3 % of drill deck workers report that they fairly often/frequently find it necessary to work at a high tempo.

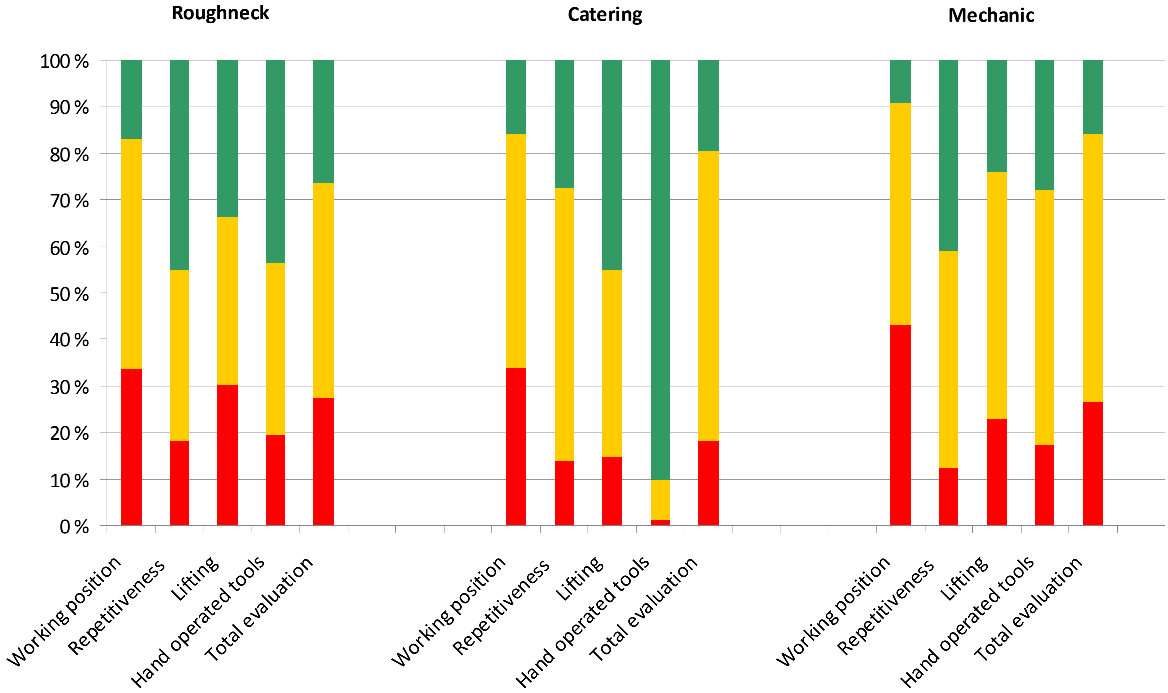


Figure 33 Risk factors from reported tasks, distributed by personnel category – mobile units

The RNNP questionnaire survey also shows that neck and shoulder pains are the most commonly reported complaints. Among surface treatment workers, 26.4 % have suffered from these complaints to a high or fairly high degree in the last three months, while for catering assistants the corresponding figure is 24.8 %. Approximately 30 % of these two groups report that they have not experienced these complaints. Among mechanics, 20.1 % report neck and shoulder pains. Back pain is something catering assistants report most: 16.3 % state that they have been troubled by back pain to a high or fairly high degree in the last three months.

For 2010, the sample relating to management of the risk of muscular/skeletal disorders and injury is slightly broader than in 2009: The number of production installations has been expanded from 19 to 22 and the number of mobile units from 19 to 31. The results show that mobile units have reported substantial improvement with reference both to planning and implementation in 2010 compared with 2009. For production installations too, improvements have taken place.

11. Other indicators

11.1 DFU21 Falling objects

In the period 2002–2010 an average of 265 events related to falling objects has been reported to RNNP each year. The number of events reported for each year remained fairly constant in the period 2002–2007 but the last three years show a slight falling trend, down to 211 events in 2010. On the Norwegian Continental Shelf there have been one fatality and 85 cases of injury since 2002 involving falling objects.

This year a comprehensive analysis has been made with the aim of classifying events in relation to initiating causes. The main period studied was 2006–2010. Classification follows the categories model developed in the BORA project, see the Main Report. This method was originally designed for the purpose of classifying hydrocarbon leaks but has been generalised and adapted to apply to events involving falling objects.

Figure 34 shows the distribution of events in main categories of work processes. Causal factors are differently distributed among the defined work processes and of special interest are crane-related events, for which cause category F: external factors accounts for almost 40 % of these events. For internal lifting operations, cause category F *external factors* is even more dominant than for crane operations as a whole (59 % against 37 %). A more thoroughgoing analysis has therefore been made of cause distribution under main category F. Events with falling objects in connection with work processes using cranes are also of particular interest since these events are concentrated in the two highest energy classes.

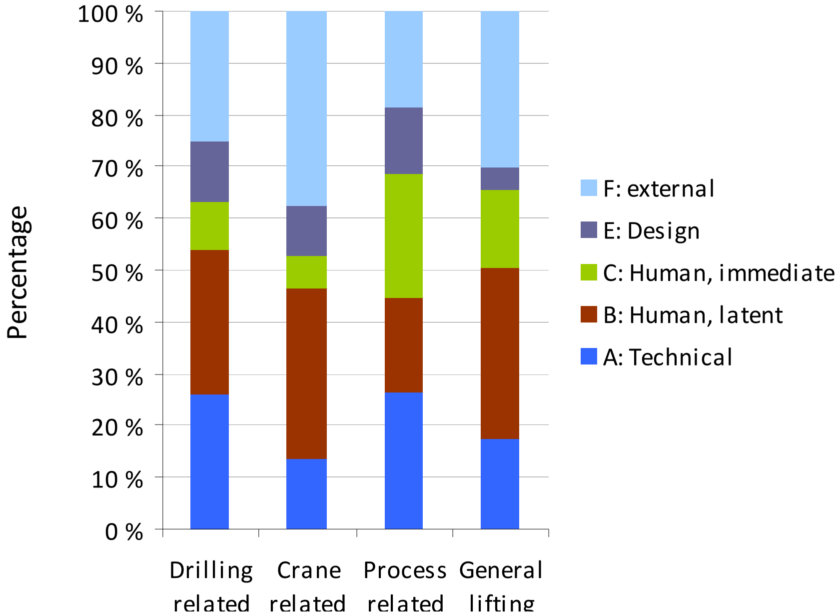


Figure 34 Triggering factors distributed by main work process categories, 2002-2010

Figure 35 shows a detailed presentation of the causes of falling objects in association with the work processes *loading and unloading operations* (from vessels) and *lifting operations* taking place internally on the installation. The data material for these work processes has been expanded to include events registered as far back as 2002. Category F3: *effect of impact/snagging* accounts for a relatively high fraction of events in the main category of crane-related work processes. A high fraction of these events is found in lifting operations on the installation itself. The Main Report contains a more comprehensive analysis.

11.2 Other DFUs

The Main Report presents data for events reported to the Petroleum Safety Authority, and for the following remaining DFUs, which have no major accident potential: DFU10; 11; 13; 16 and 19, see Table 1.

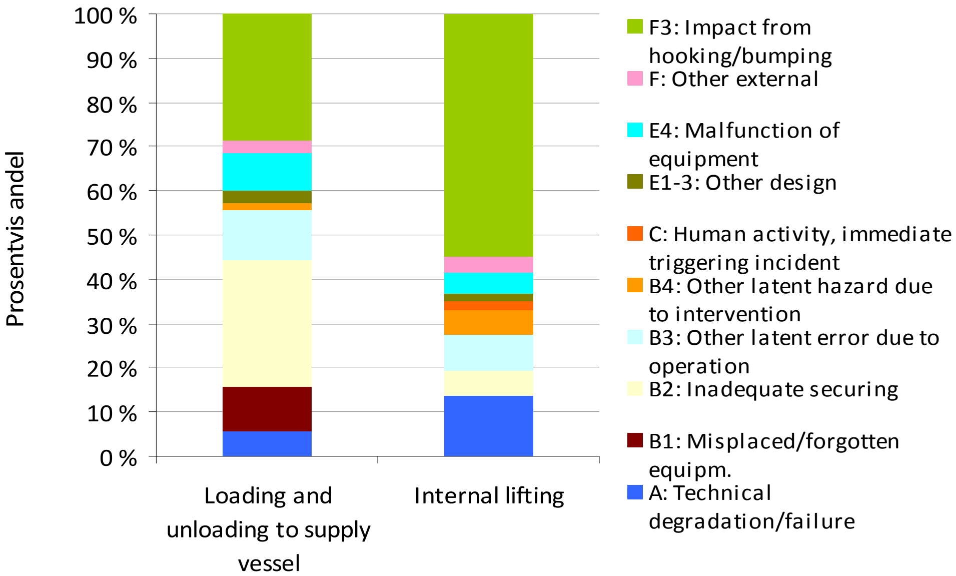


Figure 35 Triggering factors distributed by detailed work process categories, 2002-2010

12. Definitions and abbreviations

12.1 Definitions

See Subsections 1.9.1–1.9.3 and 6.2 in the Main Report.

12.2 Abbreviations

For a detailed list of abbreviations, see PSA, 2011a: Trends in Risk Level on the Norwegian Continental Shelf, Main Report, 27.4.2011. The most important abbreviations in this report are:

API	American Petroleum Institute
CODAM	Database for damage to structures and subsea installations
DDRS/CDRS	Database for drilling and well operations
DFU	Defined situations of hazard and accident
PM	Preventive maintenance
GM	Metacentre height
HES	Health, environment and safety
KPI	Key Performance Indicator
CM	Corrective maintenance
NPD	The Norwegian Petroleum Directorate
PSA	The Petroleum Safety Authority
STAMI	The National Institute of Occupational Health
WIF	Well Integrity Forum

13. References

For a detailed reference list, see the Main Reports:

PSA, 2011a. Trends in Risk Level on the Norwegian Continental Shelf, Main Report, 27.4.2011

PSA, 2011b. Trends in Risk Level – Land Facilities in the Norwegian Petroleum Activities, 27.4.2011