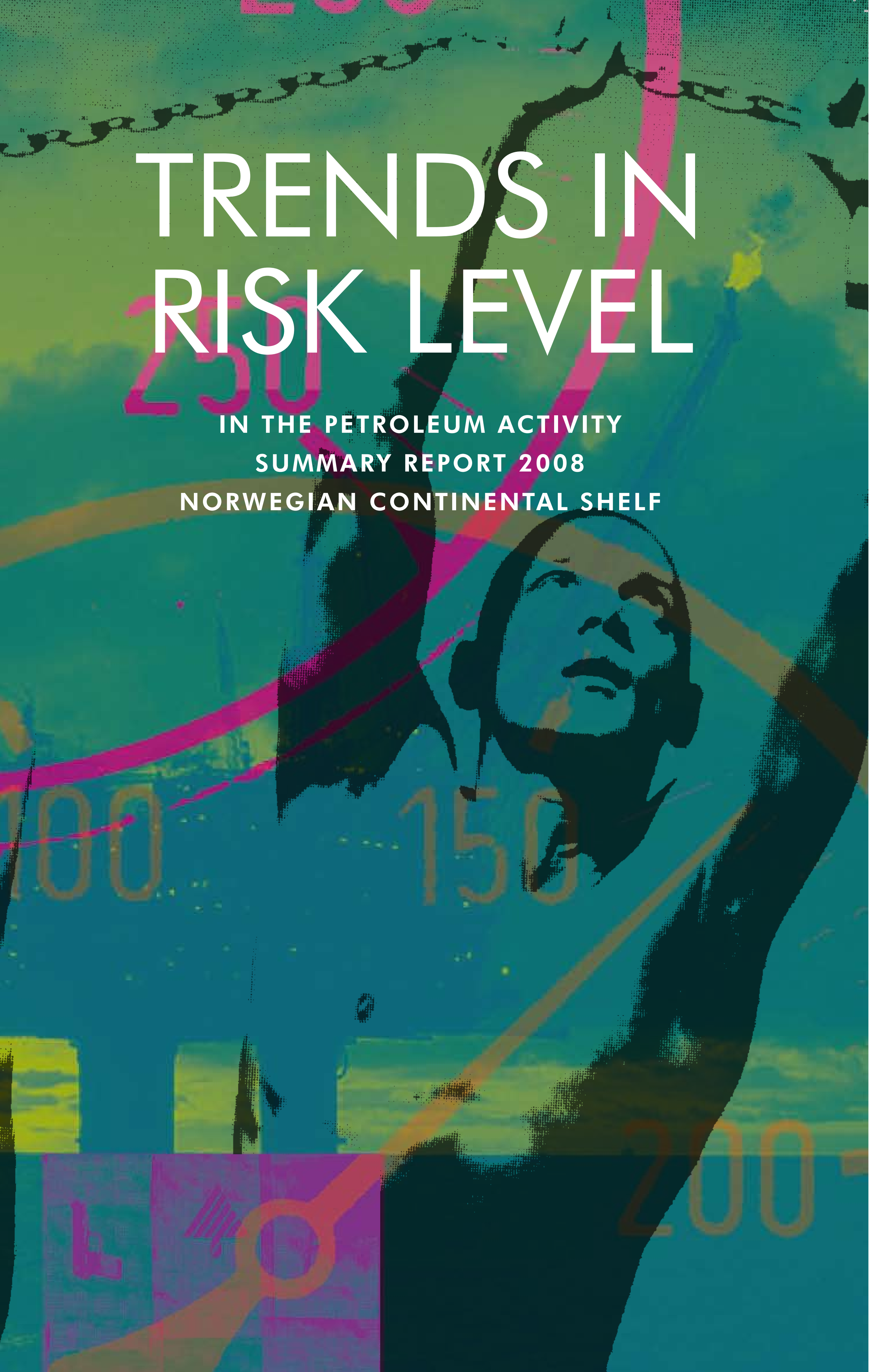
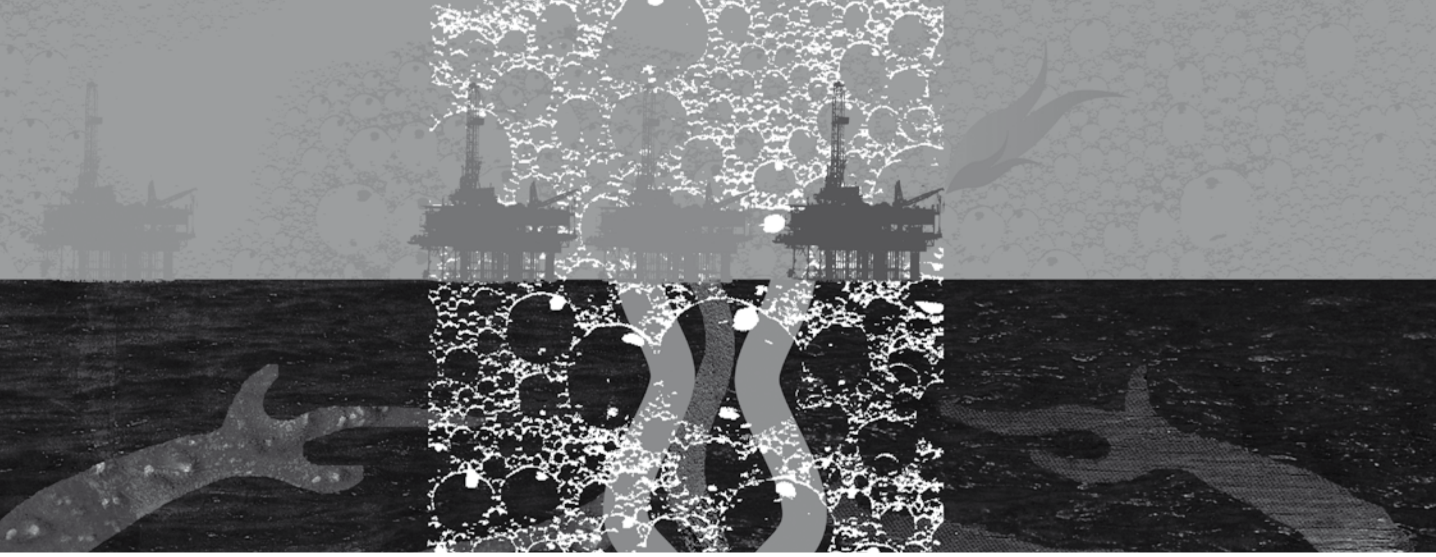
TRENDS IN RISK LEVEL

IN THE PETROLEUM ACTIVITY
SUMMARY REPORT 2008
NORWEGIAN CONTINENTAL SHELF





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 for us to establish a structure for measuring the effect of the collective HES work in the industry. Against this background, a project was launched in 1999/2000 to survey trends in risk levels on the Norwegian Continental Shelf. The initial phases of the project showed that the chosen methodology lends itself to forming a picture of these trends. This activity has come to assume an important role in the industry since it contributes to a unified understanding of risk levels by the parties involved.

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, consultant firms, research and teaching institutions to contribute to the project.

Objectivity and credibility are key words if opinions on safety and the working environment are to carry any weight. The results have been presented to the Safety Forum, where both employees' and employers' organisations and the authorities are represented. Comments so far have been positive and constructive and the expectation is that this work will contribute to a common platform for the improvement of safety and the working environment. Joint ownership of the process and results is important. To promote continuing active ownership of the process, a reference group representing the partners in the Safety Forum will be constituted in 2009 with the mandate of contributing to the further development of the work.

The use of complementary methods for measuring trends in risk levels makes this survey unique. Building further on this methodological approach is an important precondition for the success of the work.

To the best of our knowledge, the work is also unique in that its aim is to measure risk for an entire industrial sector. We have limitations in regard to time and the information available to us. Although the survey results are gradually improving in quality, they must still be applied with a degree of caution.

There are many people, both in and outside the industry, who have contributed to the survey. 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, 23rd April 2009

Øyvind Tuntland
Director for Professional Competence

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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 gradually gone 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 installations, 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 making 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 purposes of the present report, 21 persons were interviewed in January and February 2009.

The activity is limited to factors which fall under the PSA's area of authority in regard to safety and the working environment, and all helicopter transport of personnel, in cooperation with the Civil Aviation Authority Norway and helicopter operators on the Norwegian Continental Shelf. The survey 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 from 1.1.2006. Data acquisition started from that date and separate reports have been published for the last 3 years containing the results and analyses for land facilities.

2. Conclusions

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

Our primary focus is on trends. Taken by themselves, it is to be expected that some indicators, particularly within a limited area, 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 measurement tools. In practice this often proves complicated, partly because the indicators reflect HES factors on sometimes widely-differing 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 and falling objects
- Serious injury to personnel
- Perceived risk
- HES culture
- Occupational illness and injury
    - o Chemical work environment
    - o Noise-related injury
- Qualitative information relevant to the above

In 2009 we conducted an interview survey in which members of the safety forum, L-8 and four other informants (21 persons in all) were interviewed about selected HES topics. Corresponding interviews were conducted in 2001, 2002 and 2003.

All our informants report having experienced a positive trend in the petroleum industry during the last five years, on both offshore and land facilities. Most of them stress that there is greater emphasis on HES today than in previous years and that a culture of safe working has been created. The decrease in the number of events, particularly in relation to gas leaks, is specifically mentioned. In the informants' experience, greater attention is now paid to major accidents and the importance of management in preventing major accidents and learning from events. Informants note that greater heed is now paid to the health risk from chemicals. The encouraging results from the introduction of common procedures are emphasised and, not least, close cooperation between the social partners is seen as playing a key role in achieving improvements in HES. The Safety Forum and Working Together for Safety are also acknowledged to play an important role.

The major accident indicators point to a positive trend in recent years. The industry has focused on reducing the number of hydrocarbon leaks. Clear reduction targets have been set on two occasions: first a maximum of 20 leaks greater than 0.1 kg/sec in 2005, then a maximum of 10 leaks in 2008. This latter target was met in 2005 and in 2007. 10 leaks of this kind were registered. There was again a slight increase (12) in 2008 but the level is still statistically significantly lower than the average for the period 2001-2007. This shows that it is possible to achieve excellent results through concentrated work.

The indicator for well control events also points to a generally positive trend in recent years. If we take the potential contribution from this type of event in relation to loss of life, we see it is at its lowest level in this period. In general, the number of incidents with major accident potential shows a slight rise in 2008 over 2007. If we combine frequency and potential for loss of life related to the same incidents, an increase in mean value is also observable for the last three years compared with the preceding three-year period but overall the level is now significantly lower than the average for the period 2001-2007.

We note that the trend in the indicators for major accident coincides with the picture presented by our informants with regard to trends and the focus on major accidents and level of risk.

In 2009 there have been several serious helicopter accidents associated with petroleum activities. On 12th March there were 17 fatalities when a Sikorsky S-92 ditched into the sea off Newfoundland and on 1st April 16 persons lost their lives when a Super Puma L2 helicopter ditched off the Scottish coast On 18th February the pilots of a Super Puma EC-225 performed a controlled landing in the sea on the ETAP Field off Scotland. All 18 people on board were rescued. In Norway, a controlled emergency landing was performed with a Sikorsky S-92 on Tor on 8th April.

Helicopter-related risk accounts for a major part of the total risk offshore personnel are exposed to. These events show in all clarity the importance of maintaining a sharp focus on helicopter safety.

In general the industry is tending now to turn its attention to pro-active (leading) indicators, i.e. indicators that provide information about robustness in relation to capacity for withstanding potential events. Our barrier indicators are typical examples here. The barrier indicators show that there is substantial variation between the different installations, some having relatively poor results for certain barrier systems – a level indicating keener focus on barrier status. 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.

In keeping with the indicators for major accident, serious injury indicators point to a positive trend in recent years. Injury frequency is now 0.86 cases per million manhours, significantly lower than the average for the preceding ten-year period. Injury frequency on mobile units is more than twice as high as on production installations.

The noise indicator shows no improvement for 2008 although some installations have achieved clearly improved results in 2008. On production installations there has been a marked decline in planned activities aimed at reducing the risk of noise-related injuries, while mobile units show a slight improvement. The number of reported cases of noise-related injury is alarmingly high, although we must take into account that changes in reporting criteria may partly account for the high figure.

Part 2: Implementation and Scope

3. Implementation

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

- The qualitative study consists of interviews with key resource persons in the industry, with the aim of eliciting their assessment of trends in risk level over the last five years.
- 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. With regard to helicopter transport there are some changes in the basis for the data reported from and including 2008.
- A substantial quantity of experience data has been acquired for barriers against major accidents and analysed as in the period 2003-2007. There is a new indicator for well status, developed in cooperation with the industry.
- Indicators for noise exposure have been followed up as before while there are some changes in the indicators for chemical work environment.
- Data from land facilities have been analysed and presented in a separate report.

3.1 Implementation of the Work

Work on the present report began in summer 2008 and involved the following participants:

- <u>The Petroleum Safety Authority:</u>
Responsible for implementation and follow-up of the work
- <u>Operator companies and shipping companies:</u>
Provide data and information on activities on the installations and contribute to the work of adapting the model for land installations, which have been included from 1.1.2006
- <u>Civil Aviation Authority Norway:</u>
Responsible for the reporting of public data on helicopter activities and quality assurance of data, analyses and conclusions
- <u>Helicopter operators:</u>
Provide data and information on activities in the helicopter transport sector
- <u>HES expert group</u> (selected specialists):
Evaluate methods, databases, views on development, evaluate trends, propose conclusions
- <u>The Safety Forum</u> (representing unions, employers and authorities):
Comment on methods, procedures and results and make recommendations for further work.
- <u>Advisory group:</u> (representing unions, employers and authorities):
This group will be established medio 2009 to advise the Petroleum Safety Authority on the continuation 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, Jon Andreas Hestad, Peter Ellevseth and Eva Kvam, Safetec
- Kari Skarholt, Lisbeth Hansson, Irene Wærø, SINTEF Teknologi og Samfunn, Stian Antonsen, Jørn Fenstad, NTNU Samfunnsforskning – Studio Apertura

The PSA working group is composed of: Einar Ravnås, Øyvind Lauridsen, Sissel Østbø, Birgit Vignes, Arne Kvitrud, Irene B. Dahle, Hilde Nilsen, Jon Arne Ask, Inger Danielsen, Elisabeth Lootz, Sigvart Zachariassen and Torleif Husebø.

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

- Evelyn Westvig, Civil Aviation Authority
- Øyvind Solberg, CHC Helicopter Service
- Inge Løland, Per Skalleberg, Bristow Norway AS

Various other people have contributed to the implementation of the work, for example in connection with the round of interviews.

3.2 Use of Risk Indicators

Data have been collected for 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
- Accidents and events in helicopter transport activities
- Occupational accidents
- Noise and chemical work environment
- 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 five 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 the existing Petroleum Safety Authority databases (CODAM, DDRS, etc.) but also to a considerable extent on data acquired in cooperation with the operator 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 employed the same categories for registering data through the Synergi database.

3.3 Trends in Activity Level

Figure 1 and Figure 2 show trends over the period 1996-2008, for production and exploration activities, of the parameters used for normalisation against activity level (relative figures, year 2000 is put at 1.0). Annex A of the Main Report (PSA 2009a) presents the basic data in detail. Any errors in the data material in earlier reports have been corrected.

Table 1 Overview of DFUs and data sources

DFU no.	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	H2S emission	Data acquisition*
21	Falling object	Data acquisition*

* Data acquired with the cooperation of operator companies

Figure 1 Trends in activity level, production

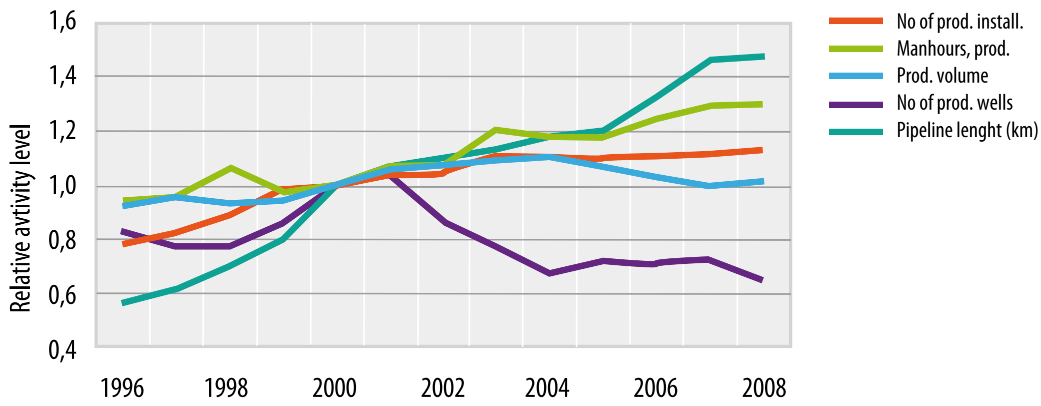
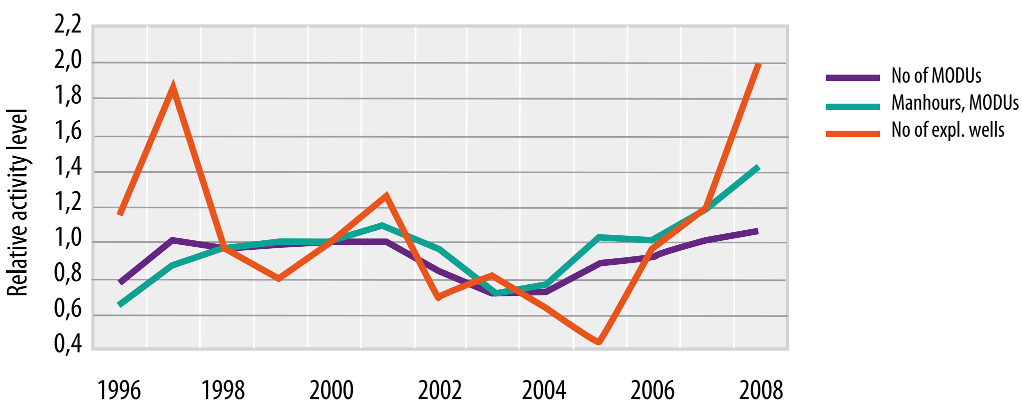


Figure 2 Trends in activity level, exploration



Changes in activity level in relation to the individual parameters are dissimilar, the number of manhours on production installations having increased by 30 % while there is a 30 % reduction in the number of production wells. On mobile units the variations from year to year are even greater. 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.

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 2008 (Norwegian and English versions)
- Project Report – Norwegian Continental Shelf for 2008
- Land Facilities Report for 2008

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

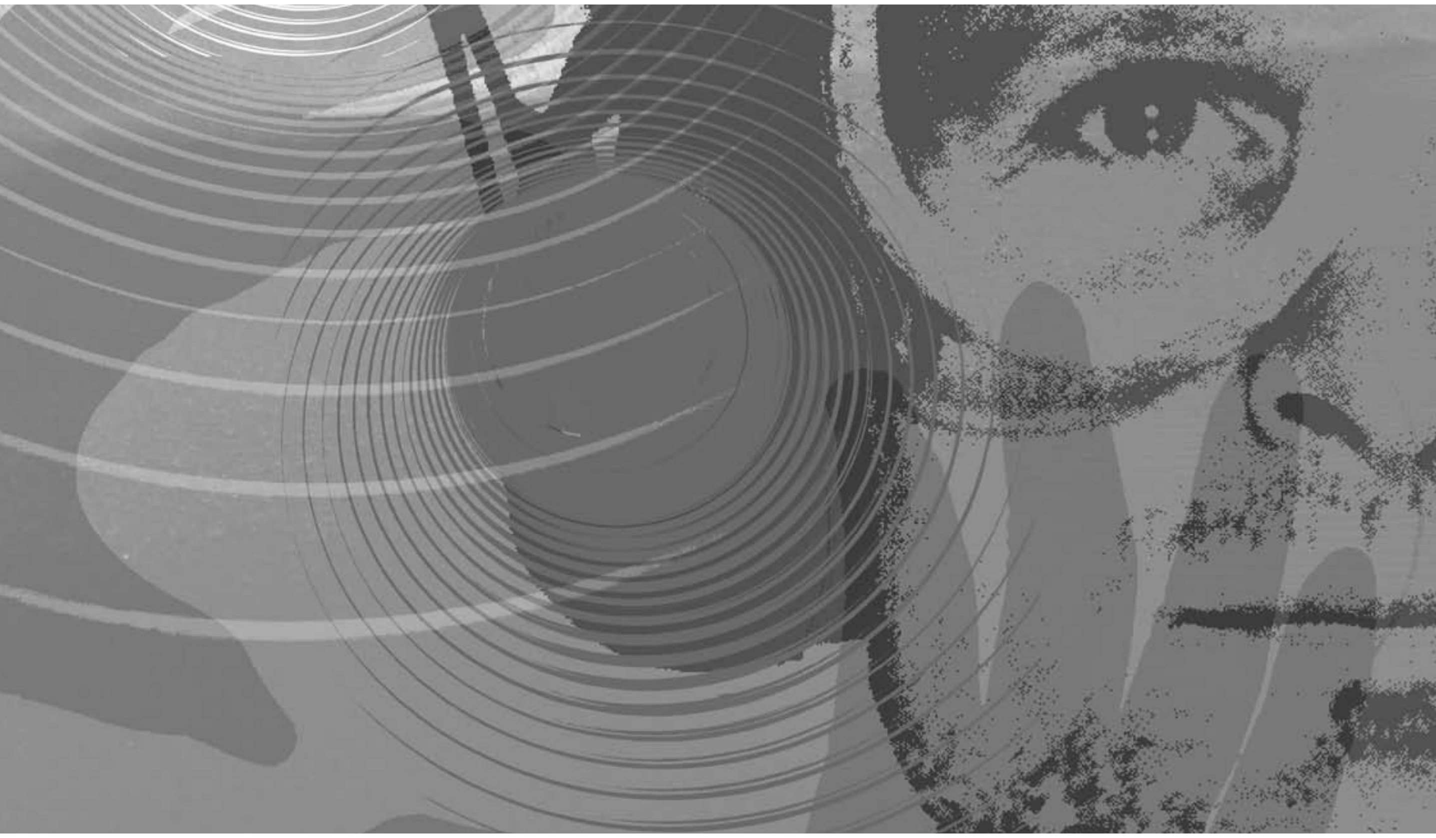
4. Scope

The qualitative study takes the form of interviews with key resource persons in the industry, aimed at eliciting their perception of trends in risk level over the last five years.

The methods used for statistical analysis in previous years have been continued, with only slight changes. There is a new indicator for well status, developed in cooperation with the industry. The work on serious injury related to occupational accidents has also been continued as before.

Noise indicators remain unchanged from the last few years while slight changes have been introduced in 2008 for the indicators of chemical work environment, see Section 0.

Part 3: Results from 2008



5. Qualitative Indicators and Analyses

5.1 Background and Assumptions

As part of the RNNP for 2008 a round of 21 interviews was conducted with members of the Safety Forum and L-8, and other resource persons from the petroleum industry. The Safety Forum is the main cooperation arena for the employers' and employees' representatives in petroleum activities and the authorities. L-8 is a cooperation arena for land facilities in the petroleum industry, in which HES management of land facilities is represented.

In years 2001, 2002 and 2003 corresponding interviews were conducted with members of the Safety Forum and key HES experts from the petroleum industry. Over the last five years there have been major structural, technological and organisational changes in the branch. It was therefore PSA's wish that members of the Safety Forum and selected experts should be interviewed once more to elicit their assessment of risk levels during the past five years. Selected members of L-8 have also been included in the survey because we felt it was important to present a picture of HES trends in the land facilities. In 2003, the last time corresponding interviews were conducted with members of the Safety Forum, onshore facilities were not under PSA's area of supervision. The 2003 report therefore includes no discussion of the situation relating to land facilities.

5.2 HES Factors, General Comments

5.2.1 Positive trends in risk level

Representatives from the employers, the unions and the authorities all say that in their experience there has been a positive trend in the branch over the last five years, despite some levelling off with no striking improvement discernible. Most of those interviewed make the point that there has been greater emphasis on HES than in previous years and that a culture has been created of safe working. There is a reduction in the number of events relating to key indicators: gas leaks and well incidents are particularly mentioned here. Other positive factors are given as: greater heed to, and understanding of, the risk of major accident, more systematic management training aimed at preventing major accidents, closer attention to health risk from chemicals and better risk assessment through the application of common practices and procedures. Last, but not least, cooperation between the partners in the industry was highlighted as a key to continuing improvement in the safety area, particularly Working Together for Safety and the Safety Forum. The Safety Forum has extended its membership to include the partners in the industry from land facilities. An important finding from the survey is confirmation from these new representatives that they are included and listened to on an equal footing with the other members.

Although some representatives on the employees' side maintain that risk relating to personal injury is still over-prioritised in proportion to major accident risk, it is interesting to note that the social partners agree this year that the major accident perspective has assumed greater importance and that a more preventive approach has been adopted through learning from events. The Texas City event has played a part in bringing about this change of direction, according to informants from both the employers' and employees' side.

The representatives from L-8 say that the risk picture on the land facilities shows a positive trend. There are higher ambitions for the land facilities – with sharper focus on the part of management and more uniform HES prioritisation. This was qualified by comments that there is a difference between facilities built in the 1960s and those of more recent construction and that risk on the newer facilities is perceived as lower.

5.2.2 Important HES challenges today and in future

We have asked our informants what they see as the most pressing HES challenges today. From their statements we can highlight the following as key elements on both offshore and onshore installations:

- Management and understanding of risk
- Competence deficiencies
- Changes in player participation
- Compliance with procedures
- Maintenance management of older installations and facilities

Despite the fact that major accident risk has been given greater emphasis and that there is now a more systematic approach to learning from serious accidents, there remains scope for improvement. Our informants feel strongly that the industry has potential for improvement with respect to learning from events. This is also a matter of keen concern to PSA. In PSA's investigation of events with major accident potential, failure to observe procedures is a recurrent finding.

A further and very important HES challenge raised by all sides, operators and contractors alike, is competence deficiency. Relevant training and updating of contractor personnel is especially mentioned. Lack of competence is also associated with a high level of activity, with the introduction of new players and the rapid growth of some contractor companies. Our informants express concern that inadequate training in recent years may have adverse consequences for HES.

Changes in the player picture resulting from the Statoil-Hydro merger and the entry into Norwegian petroleum activities of smaller oil companies and contractor firms may present a challenge in the years ahead. The PSA has an important supervisory role here, especially in relation to smaller companies with less experience of Norwegian petroleum operations than the larger and more experienced players.

Through its auditing activities, the PSA has documented deficiencies in maintenance management. Maintenance management and the need to take account of aging offshore installations and land facilities and the extended life of offshore installations also present a substantial safety challenge now and in the future, in our informants' view.

In the interview data from 2001, 2002 and 2003 we find a clear contrast between employers and employees in the causal factors they identify in relation to personal injury and major accident risk. The unions were then chiefly preoccupied with involvement, secure employment and good working conditions for employees. Company representatives were more concerned with individual factors such as attitudes, behaviour and management training.

It is interesting to note that in this year's interview data this former opposition is no longer found. In their descriptions of major HES challenges and how to approach them, greater emphasis is now also discernible on the employers' side on structural factors such as organisation and technology. Individual factors are played down and the "iceberg theory" no longer plays such an important role as the basis for HES work. The parties concur that the major accident perspective has come to dominate and that the iceberg theory has been correspondingly toned down. This probably contributes to a greater degree of accord between the parties.

Most of our informants believe RNNP to be an important project, a view held by representatives from both the employers' and employees' side and by the Petroleum Safety Authority. The possibility afforded by RNNP to monitor risk trends at aggregate level is the aspect highlighted by most informants. Some points for improvement have nevertheless been identified in the questionnaire survey, mainly by representatives from the land facilities. The RNNP survey first included land facilities in 2007/08. Representatives from these facilities say that adapting the survey to make it more relevant to onshore operations is the most important area for improvement.

6. Status and Trends – DFU12, Helicopter Events

The project's cooperation with the Civil Aviation Authority and helicopter operators was taken a step further in 2008, with some changes resulting from the introduction of the companies' new computer system for reporting of events, Sentinel. Aviation data gathered 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, 2009a) 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 there have been several serious helicopter accidents in the petroleum industry at large. On 12th March there were 17 fatalities when a Sikorsky S-92 ditched in the sea off Newfoundland and on 1st April 16 persons lost their lives when a Super Puma L2 helicopter ditched off Scotland. On 18th February the pilots of a Super Puma EC-225 performed a controlled emergency landing in the sea on the ETAP Field off Scotland. All 18 persons on board were rescued. In Norway, on 8th April, a Sikorsky S-92 made a controlled emergency landing on Tor.

Helicopter-related risk accounts for a major proportion of the total risk an offshore worker is exposed to. These events show in all clarity the importance of maintaining a sharp focus on helicopter safety.

Three event indicators and two activity indicators have been established to give the best possible picture of helicopter risk. The activity indicators show the trends in exposure to helicopter risk and are thus more proactive indicators. Indicators are fully explained in the Main Report.

The indicators used in this work point to no clear trends with respect to trends in risk level. It is also important to note that this type of indicator is not capable of picking up short-term changes in event frequency.

6.1 Activity Indicators

Figure 3 shows activity indicator 1 (crew change traffic) and activity indicator 2 (shuttle traffic) with the number of flight hours and the number of person flight

Figure 3 Volume of crew change traffic and shuttle traffic, person flight hours and flight hours, 1999-2008

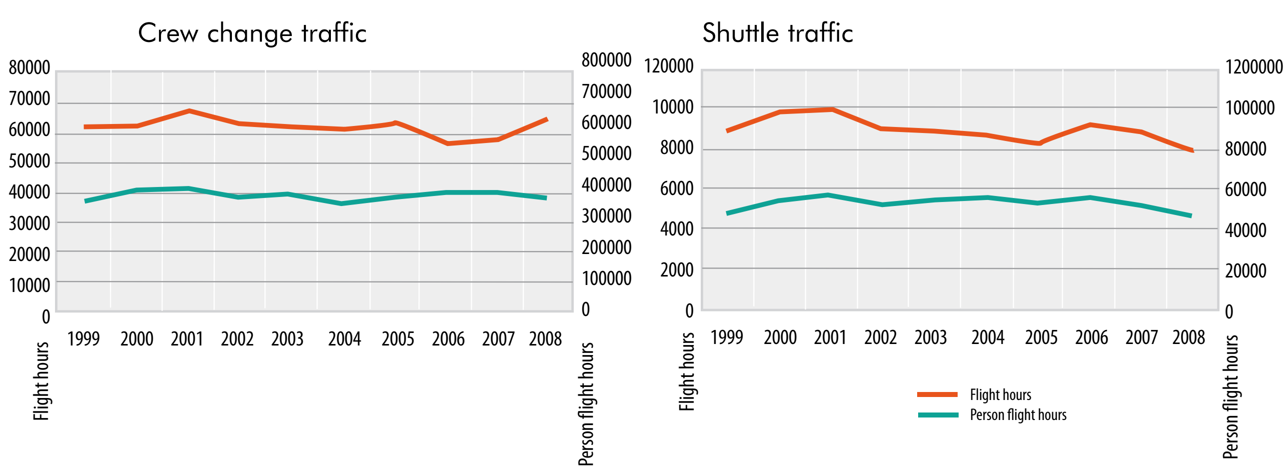
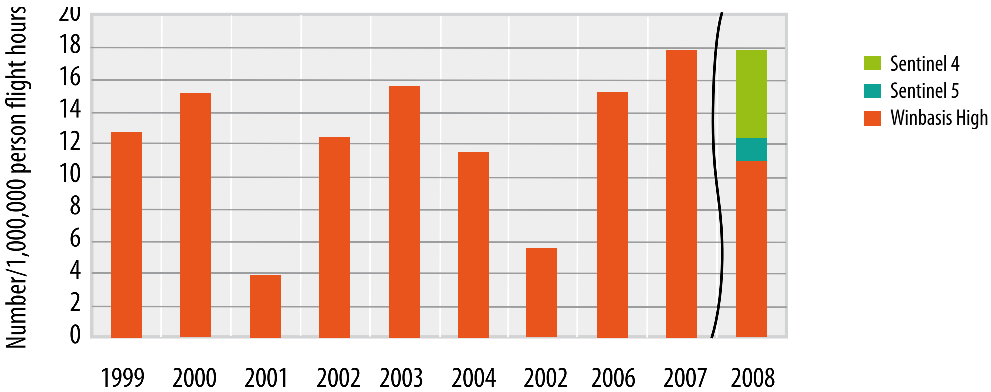


Figure 4 Event indicator 1, per 1 000 000 person flight hours, 1999-2008



hours per year in the period 1999-2008. For crew change traffic there were fewer variations in the period as a whole, with no clear trends. Data have been partly corrected for 2006 and 2007. There was an increase in the volume of shuttle traffic up to 2001, followed by a reduction in person flight hours and a stable level of flight hours.

Activity indicator 1, volume of crew change traffic per year, must be seen in relation to activity level on the Norwegian Continental Shelf. In 2008 activity level (manhours) on the Norwegian Continental Shelf increased by approximately 5 %, while the number of flight hours was reduced by approximately 4.4 %, and person flight hours increased by 10.9 %. These differences can be explained by more effective use of helicopters and the capacity of the new helicopters to take off with maximum passenger load in virtually all weather conditions.

Some installations suffer from lack of space and shuttle traffic is therefore part of the everyday routine. Most shuttle traffic is on the Ekofisk Field. In some cases shuttle traffic is flown using larger helicopters than previously. This may partly explain the decrease in the number of flight hours.

6.2 Event Indicators

6.2.1 Event indicator 1

Figure 4 shows the number of events covered by event indicator 1 normalised in relation to the number of million person flight hours per year. In the Main Report the corresponding trend is also shown per 100 000 flight hours.

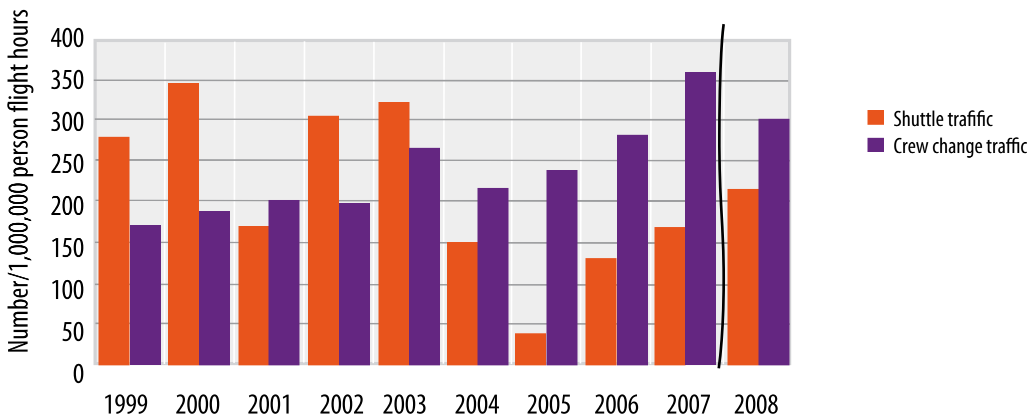
Event indicator 1 covers the most serious events per year in the period 1999-2008. Events in risk class minimal and events in which the helicopter is in parked phase are not included. For 2008 events reported in the database Winbasis will be included in the same way as before. For events reported in Sentinel those in the two highest categories of severity will be included in event indicator 1. From 1999–2007 only aviation incidents and significant operational disruptions will be included. Previously, aviation incidents of medium and low severity were included in event indicator 1 (19 and 3 events respectively for these years as a whole). Since there have been changes in reporting criteria from 2008, it is made clear in the figures that there was a break in reporting from 2007 to 2008, which means it is not possible to identify trends beyond 2007.

The change introduced from 2008 indicates that Event indicator 1 is better suited to expressing the risk potential of events but is still not considered to be a sufficiently good indicator of helicopter risk, particularly in relation to the improvements in redundancy and robustness characteristic of the new helicopter types. Further work is planned to improve these indicators.

6.2.2 Event indicator 2

The event types covered by Event indicator 2 are the same as for Event indicator 1 together with operational disruptions of medium and low severity reported in Winbasis, and events of severity class 2-5 for events reported in Sentinel. Events reported in Winbasis with risk class minimal are not included. Event indicator 2 also covers events in which the helicopter is in the parked phase. Figure 5 shows the number of events included in Event

Figure 5 Event indicator 2, per 1 000 000 person flight hours, 1999-2008



indicator 2 normalised in relation to the number of million person flight hours in the period 1999-2004. (In the Main Report the corresponding trend is also shown per 100 000 flight hours.)

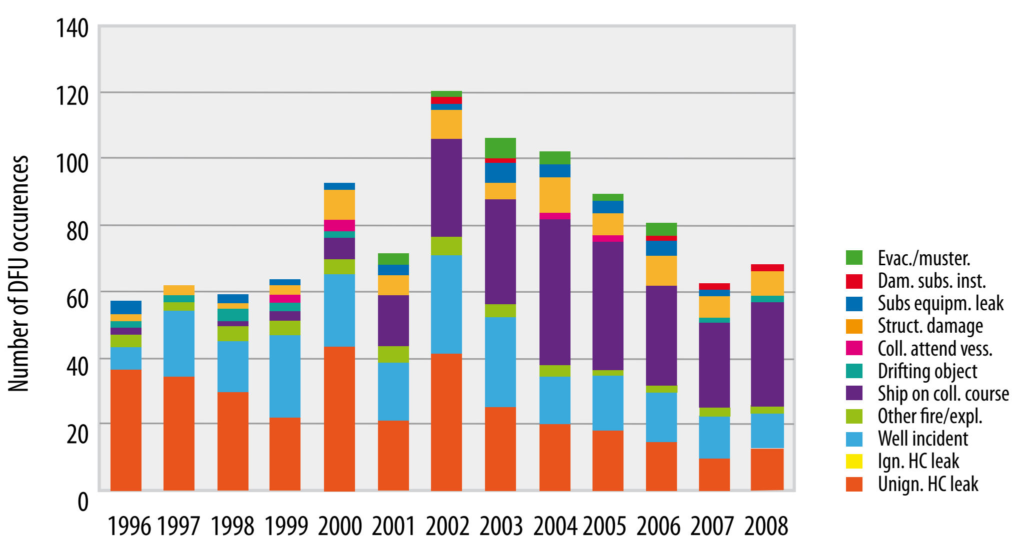
There has been a slight increase in the number of events relating to crew change traffic throughout the period. For shuttle traffic the picture is that of variations around a stable level but the number is lower than in the period 2004 – 2008. Because there are fewer events, the variations are also greater. One possible reason for the trend in 2004-2008 is the greater focus by helicopter operators on preventing events associated with shuttle traffic. For example, one of the helicopter operators has introduced "combination flights", i.e. pilots fly both shuttle traffic and crew change traffic. Previously, shuttle traffic was mainly flown with dedicated helicopters and crew.

Another reason may be related to the introduction of a system for helideck monitoring and, not least, the standardisation and competence development resulting from the introduction of the OLF Helideck Manual for the Norwegian Continental Shelf. There was an increase in the number of events in the "parked" phase in 2002-03: see Event indicator 3 in Subsection 5.4.3 in the Main Report. After 2003 the number has remained fairly constant at 3-4 events per year, and in 2007 and 2008 there has only been one incident in the parked phase, suggesting that the measure has been effective.

7. Status and Trends – Indicators for Major Accidents on Installations

The indicators for major accident risk developed in earlier phases have been continued, with the main emphasis on indicators for events and incidents with potential for major accident. Indicators for major accident risk with helicopter are discussed in Section 6.

Figure 6 All reported DFUs distributed by category



There have been no major accidents, by the project's definition, on installations on the Norwegian Continental Shelf after 1990. None of the DFUs for major accident risk on the installation have involved 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 9 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.

The most important individual indicators for production 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 0.

7.1 DFUs related to Major Accident Risk

Figure 6 shows the trend in the number of reported DFUs on installations in the period 1996-2008. It is important to emphasise that these DFUs vary widely in their contribution to risk.

The average level after 2000 is higher than the average for the period 1996-99. The level after 2002 shows a stable decrease and in 2007 was on a par with the level for the period 1996-99. The number of incidents increased by 10 % in 2008 but is still below the level for 2000-06. In particular, DFU5 (vessel on collision course) has been underreported in previous years, in our view. This applies to a lesser extent to the DFUs relating to hydrocarbon leaks and loss of well control. Figure 6 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) in Figure 6 is not a reliable indication of trends in risk level (see the discussion in Subsection 7.2.3).

7.2 Risk Indicators for Major Accidents

7.2.1 Hydrocarbon Leaks in the Process Area

Figure 7 shows the total number of leaks exceeding 0.1 kg/s in the period 1996-2008. Up to 1999 there was a falling trend, succeeded by a period of wide variation from year to year. There was a substantial drop after 2002, but the number of leaks > 1 kg/s did not decrease to the same extent in the period 2003-05. In 2006 the number of leaks > 1 kg/s also shows a decrease, but two of the leaks were in excess of 10 kg/s. In 2008 there was one leak > 10 kg/s and the number of leaks > 1 kg/s remains unchanged, at 4 leaks. Hydrocarbon leaks are still classified by leak rate in broad bands as shown in Figure 7. In the Main Report a finer classification is also shown for the period 2001-08. The number of leaks in 2008 (12) is substantially lower than for the period 2003-05 (21 a year on average). 10 leaks a year was OLF's objective for the end of 2008 and this was achieved in 2007. One company has experienced a doubling in the number of leaks from 2007 to 2008 and this explains the total number of leaks in 2008.

Figure 7 Number of hydrocarbon leaks exceeding 0.1 kg/s, 1996-2008

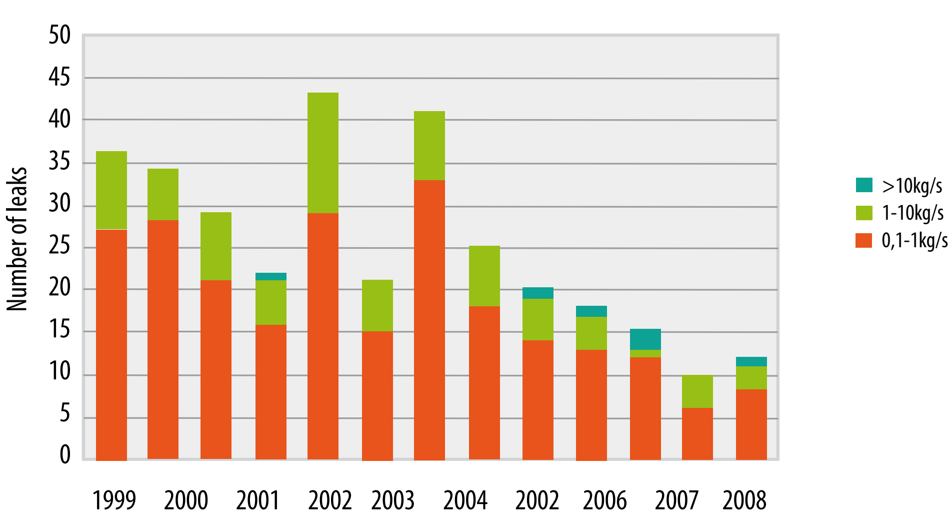


Figure 8 Hydrocarbon leaks exceeding 0.1 kg/s, 1996-2008, weighted by risk potential

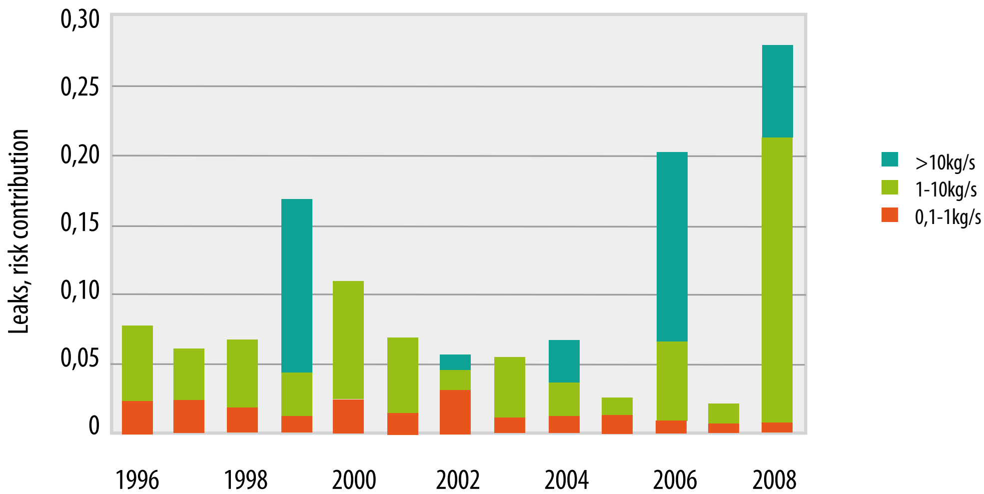


Figure 8 shows the number of leaks when weighted in relation to the contribution to risk they are reckoned to give. In simplified terms, the risk contribution from each leak is approximately proportional to the leak rate given in kg/s. Leaks exceeding 10 kg/s therefore make the biggest contribution, 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 2008 there were two leaks in particular which were calculated on the basis of their circumstances, one over 10 kg/s and one in the interval 1–10 kg/s. The leak in the interval 1–10 kg/s was the leak in the utility shaft on Statfjord A in May 2008, resulting in a potentially explosive atmosphere in the shaft immediately below the living quarters. This leak has thus been given a higher weighting than the leak rate might indicate. The contribution to risk from leaks is therefore the highest in the period since 1996.

Figure 8 shows the trend for leaks over 0.1 kg/s, normalised against installation year, for all types of production installations. The figure illustrates the technique universally used to analyse the statistical significance (robustness) of trends. Figure 8 shows that the reduction in the number of leaks per installation year is statistically significant in year 2008 compared with the average for the period 2001-07, despite the slight increase from 2007. If it had been related to the period 2003–07, the reduction would not have been statistically significant. This is shown by the fact that the height of the column for 2008 falls in the lowest, dark grey field (see Subsection 2.3.5 of the Pilot Project Report). Leaks are discussed in the Main Report, normalised against both manhours and number of installations.

Figure 9 Trend, leaks, normalised against installation year, all production installations

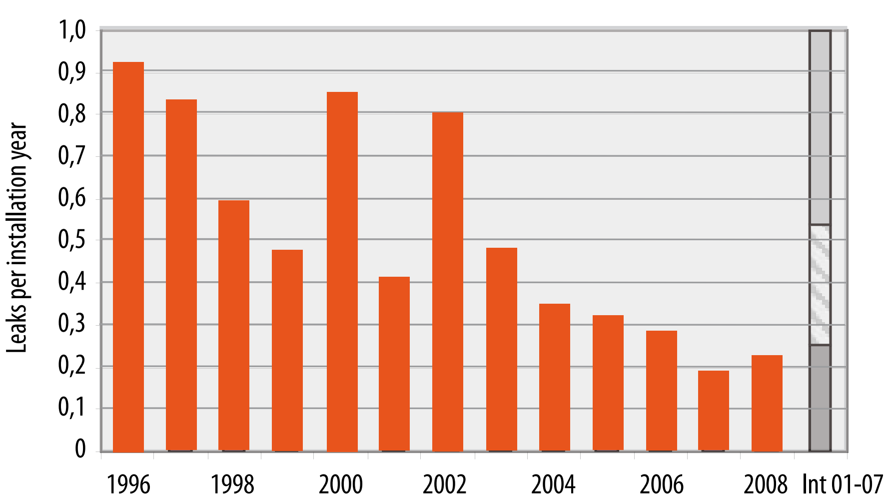
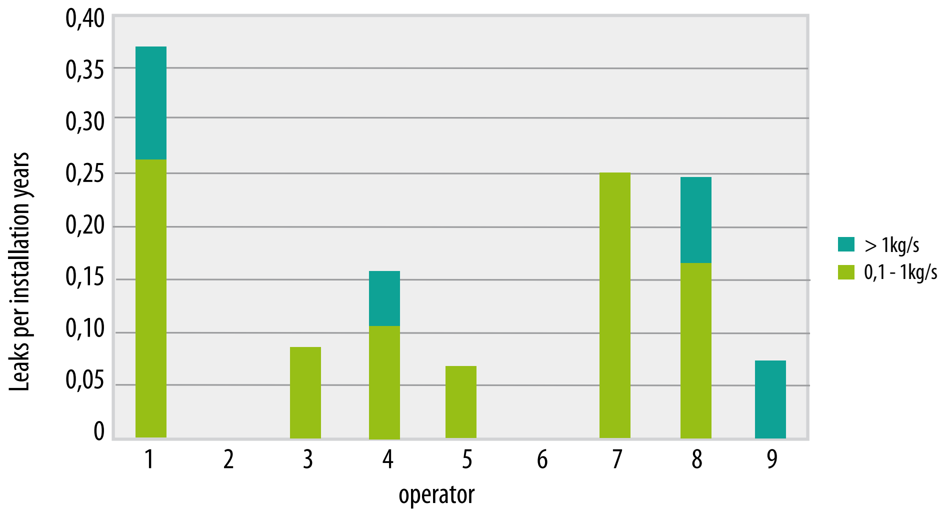


Figure 10 Average leak frequency per installation year, 2003-08



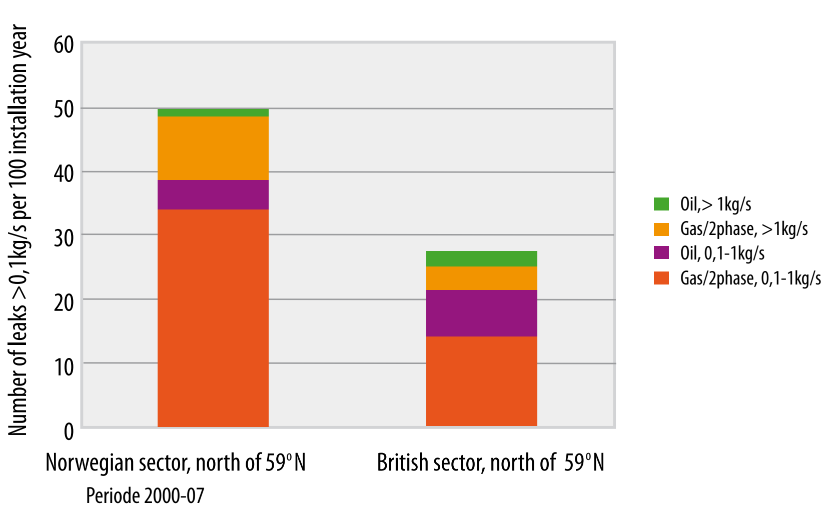
The frequency of hydrocarbon leaks over 0.1 kg/s shows considerable variation between operators, evidence that there is still clear potential for improvement. This is also substantiated by Figure 10 which shows average leak frequency per installation year for operator companies on the Norwegian Continental Shelf. In previous years this figure has been presented for the entire period 1996 to the present day. If the period is limited to the last six years, the same companies are seen to have the highest frequencies but they no longer exceed to the same extent those of some of the other companies.

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 UK Health and Safety Executive reporting period runs to 31.3. each year. The last period for which data are available is 1.4.2007-1.3.2008.

Figure 11 shows a comparison between the Norwegian and the UK Continental Shelf, in which both gas/two-phase leaks and oil leaks are included, normalised against installation year, for the two national shelves north of 59°N. The figure applies to the period 2002-07. The data included in the figure are limited to process facilities in which oil leaks have occurred. During this period there was in addition approximately 1 leak per year in the shaft in association with storage cells in the northern sector of the UK Continental Shelf, plus 1 leak every third year in connection with tank operations on production or storage vessels. There were no corresponding leaks in the period on Norwegian production instal-

Figure 11 Comparison of gas/two-phase and oil leaks on the Norwegian and the UK Continental Shelf per 100 installation years, average 2000-07



lations but in 2008 there was a major oil and gas leak in the shaft on Statfjord A on the Norwegian Continental Shelf. The latter type of leaks are not included in the figure.

The number of leaks on the Norwegian Continental Shelf has been substantially lower in recent years meaning that the period under consideration has a certain significance. For example, the following observations can be made from the data:

- For all leaks over 0.1 kg/s the Norwegian Continental Shelf is 82 % higher than the UK Continental Shelf for average leak frequency per installation year in the period 2000-07.
- For all leaks over 0.1 kg/s the Norwegian Continental Shelf is 7.6 % higher than the UK Continental Shelf for average leak frequency per installation year in the period 2005-07.

On the Norwegian Continental Shelf no cases 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 about 400. It has been shown that the percentage 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.

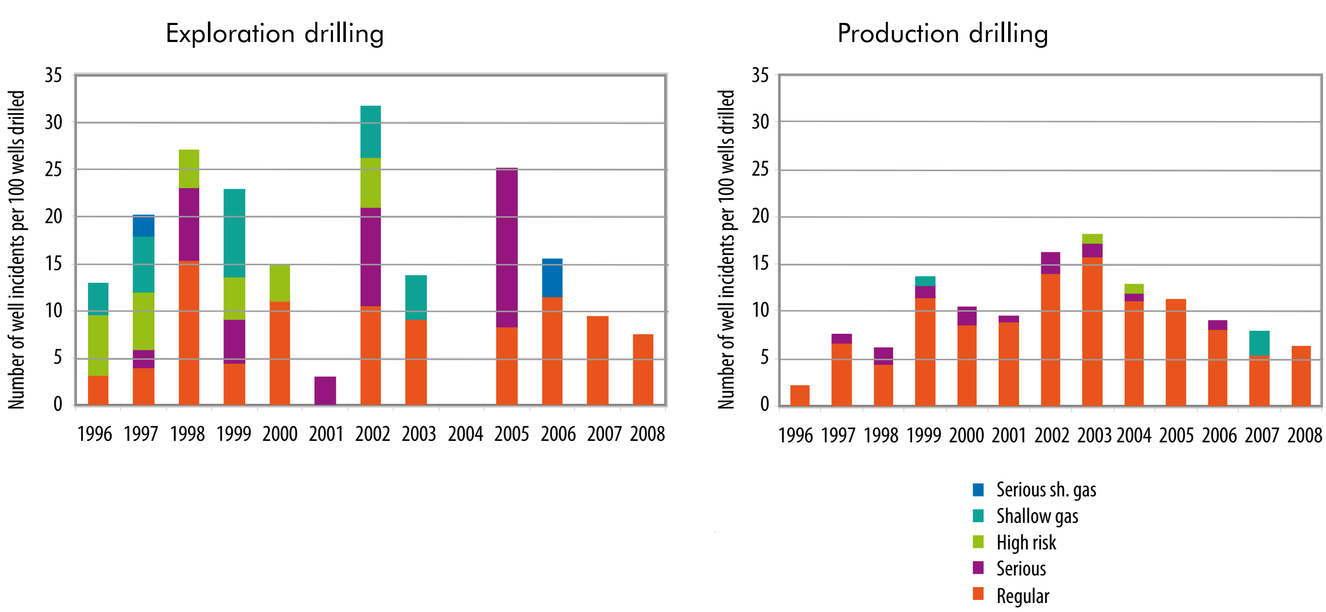
7.2.2 Loss of well control, blowout potential, well integrity

Figure 12 shows the incidence of well events and shallow gas events distributed by exploration drilling and production drilling, normalised per 100 drilled wells. Both 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 level with 1996. The last four years show a substantial reduction but this is not statistically significant. Production drilling showed a consistently increasing trend up to 2003, with minor variations. In the period from 2004 there has been a decrease, but this is not statistically significant. Taken together, well incident frequency is higher for exploration drilling than for production drilling, with the exception of years 2001, 2003 and 2004. By far the majority of well events fall into the category of regular, i.e. events with minor potential. In 2008 there were only events of this type.

The Well Integrity Forum (WIF) was constituted on 12 June 2007 as a subgroup of the Drilling Managers Forum in OLF. WIF is a forum for field operators with production wells in Norway and is used for discussion of, and cooperation on, well integrity challenges. In the period 2007-2009 WIF has worked on the following main issues:

Figure 12 Well incidents according to degree of severity per 100 wells drilled, for exploration and production drilling



- training of personnel on offshore and land facilities in well integrity fundamentals
- well integrity handover documentation for use when wells are transferred between entities
- well barrier schematics (WBS)
- establishment of measurement parameters (KPI)
- well integrity management system, criteria.

This work has resulted in the publication in 2008 of OLF Guidelines No. 117 on well integrity.

WIF conducted a pilot project in 2008 aimed at defining measurement parameters (KPI) for well integrity. Field operators reviewed all their "active" wells on the Norwegian Continental Shelf, 1677 wells in total, excluding exploration wells and permanently plugged wells. This survey was completed and reported in accordance with WIF's list of well categories, taking current definitions and subgroups per category as the basis.

WIF has adopted the following well category system:

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.

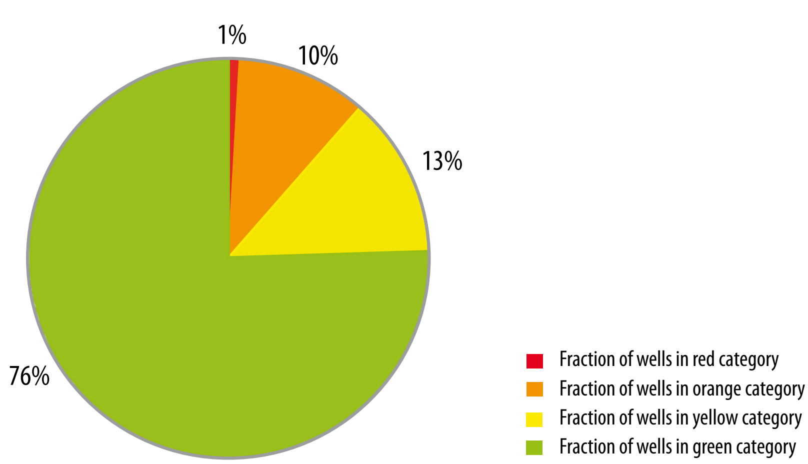
A review of active wells in relation to well integrity was performed for the first time in 2008. WIF will develop a chapter in OLF Guidelines No. 117 Well Integrity, in which the use of this matrix and the different well categories will be described in greater detail.

Eight operators were involved in the appraisal of altogether 1677 wells: BP, ConocoPhillips, Exxon Mobil Norske Shell, StatoilHydro, Marathon, Talisman and Total (in random order).

The figure shows well categories by percentage of the total number of wells (1677).

The results show that 11 % of the wells (categories red and orange) have reduced quality in relation to the requirement for 2 barriers. 13 % of the wells are in category yellow. These wells also have reduced quality in relation to the requirement for 2 barriers but the operating companies have applied a variety of measures to compensate for this, so that the 2-barrier requirement can be regarded as met. The remainder of the wells, i.e. 76 %, are in category green. These are considered to have met the 2-barrier requirement in full.

Figure 13 Well classification - category red, orange, yellow and green, 2008



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

There is a need for dialogue and clarification between the authorities and the operating companies on the results from the pilot study in the course of 2009. It should also be stressed that these indicators are part of a pilot project and that the results can only be properly addressed after the uncertainty concerning reporting criteria has been reduced.

7.2.3 Vessel on Collision Course, Structural Damage

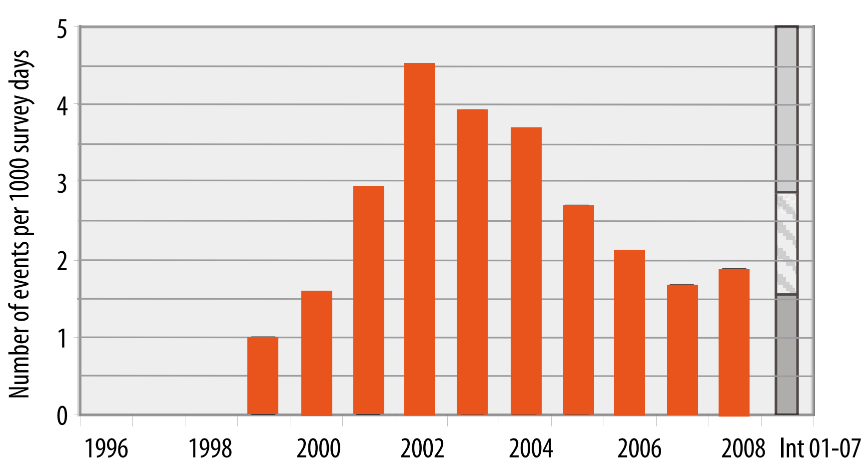
In the period before 1999 there was probably considerable underreporting of occurrences of vessel on collision course. There may still be a degree of underreporting in situations where monitoring is not done from the traffic centres at Sandsli and on Ekofisk. However, from mid-2009 there will be only four production installations and a few more mobile units where the installation itself or the stand-by vessel is responsible for monitoring passing ship traffic.

In Phase 5 a new indicator for DFU5 was introduced, by which the number of vessels reported on possible collision course was normalised in relation to the number of installations monitored from the traffic centre at Sandsli. With the introduction of the new indicator there has been a decrease since 2002. From 2008 this parameter has been adjusted slightly following suggestions from StatoilHydro Marin, with the result that the normalisation parameter, the number of installations, has been changed to the number of monitoring days. This is a more accurate parameter, especially in relation to mobile units that enter and leave the "Sandsli portfolio", according to whether or not they are in operation and for whom. The new indicator is expressed as follows:

$$\frac{\textit{Total number of registrations, DFU5}}{\textit{Total number of monitoring days for all installations monitored from Sandsli}}$$

Figure 14 shows the trend for the amended indicator, in which the number of vessels on collision course has been normalised against the number of monitoring days calculated as 1000 days. Approximate values have been calculated for the period 1999-2007, for the sake of continuity. Up to 1999 there were no observations. After 2002 a substantial decrease is noted. The main reason is assumed to be the introduction of AIS – automatic identification system for all larger ships – which makes it easier to identify them and call them

Figure 14 Number of "vessel on collision course" events in relation to the number of installations monitored from Sandsli traffic centre



up. In addition to monitoring traffic, StatoilHydro Marin maintains a substantial degree of preventive activity, including active contact with various North Sea fisheries' fora. This is probably one of the contributory factors serving to explain the post-2002 reduction. There was a slight increase in 2008 but this may be due to random variations. Installations B-7 and H-11 on the Norpipe pipeline to Emden are not included in Figure 14.

From 1996 to 2002 the number of "major" events and incidences of damage to structures and maritime systems increased, particularly in regard to mobile units. After 2002 the number of events fluctuates around a stable level. DFU8 events fall into two categories, in which a small number of the most serious events have been separated out and given a higher weighting. There were no events of this kind in the period 2005-08. The last event in this category was the failure of two anchor lines on Ocean Vanguard in 2004. The most serious event in 2008 concerned fatigue-induced cracks in the structural framework of the rig Bideford Dolphin.

It is becoming more common to have dynamic positioning systems (DP) on both vessels and installations. A high percentage of the collisions that have occurred between vessels and installations have been due to failures of, or faulty use of, DP systems. In the period from 2000 there has been on average two such events per year, with one event in 2007 and none in 2008.

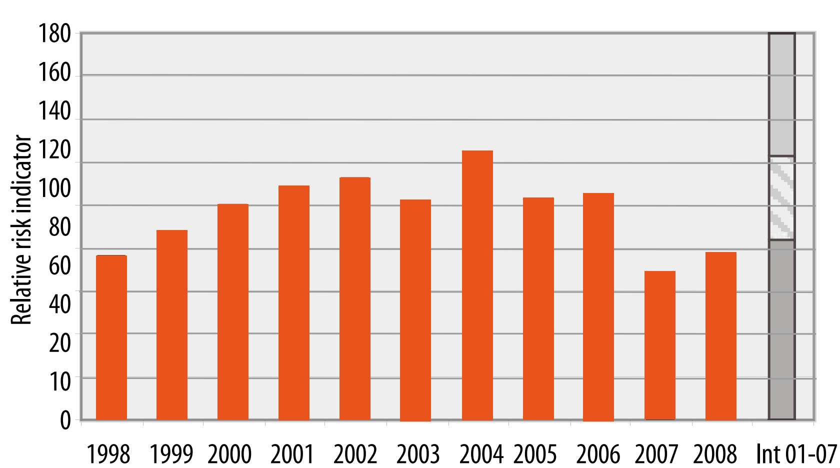
The prevailing regulations stipulate requirements for flotels and production installations whereby they must be able to tolerate the loss of two lines without serious consequences. The loss of more than one anchor line occurs from time to time and can have large consequences but rarely on such a scale as the event on Ocean Vanguard in 2004. Mobile drilling units are only required to tolerate the loss of one anchor line without unplanned consequences. Up to 2006 there was an average of more than two events per year while in 2006 there were six events of this kind. In 2007 and 2008 there was one corresponding event.

7.3 Total Indicator for Major Accidents

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

The total indicator weights contributions from observations of the individual DFUs in

Figure 15 Total indicator, production installations, normalised against manhours, 3-year rolling averages (Value put at 100 in year 2000)



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 15 shows the indicator with 3-year rolling averages. This helps to avoid large jumps from year to year and thus make the long term trend clearer.

Manhours are used as the common parameter for normalisation against activity level. The level is put at 100 in year 2000. Figure 15 shows the trend of the total indicator for all production installations.

The main impression given by the figure is that of a relatively stable level for the period, with a possible reduction over the last 3-4 years. Even taking into account the increase from 2007 to 2008, which is statistically significant, the level is lower after 2004. Individual events with substantial risk potential can result in greater variation. The leak in the utility shaft on Statfjord A in May 2008 is among events making a large contribution.

Figure 16 shows the indicator for major accident risk for floating production units. As already noted, it was especially the gas blowout on Snorre A that made a large contribution in 2004, together with the gas leak on Visund in 2006. Both events affect the value for 2006 (which is the average for the period 2004-06) but are out of the picture from 2007. The corresponding figure for production installations shows a stable level for the whole period, with a reduction in 2006 and 2007.

Figure 17 shows the trend for the total indicator for mobile units, with 3-year rolling averages. The value in 2007 and 2008 is on a par with that for 2005 and the value in 2006 represents a slight

Figure 16 Total indicator, floating production units only, normalised against manhours (Value put at 100 in year 2000)

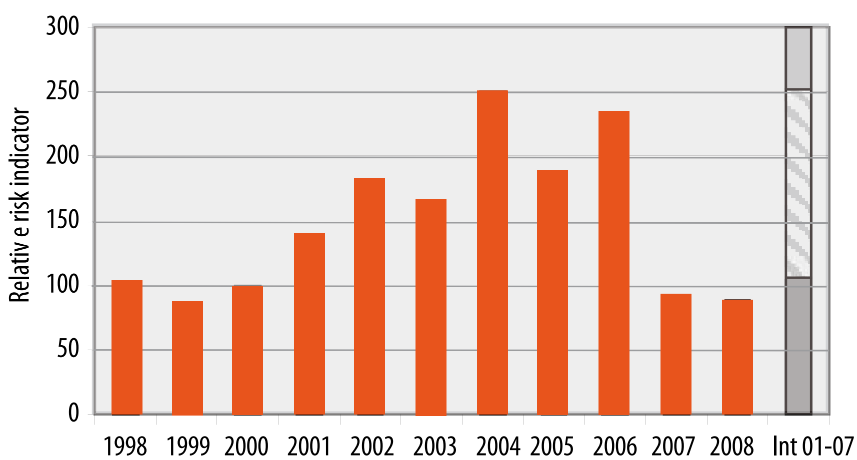
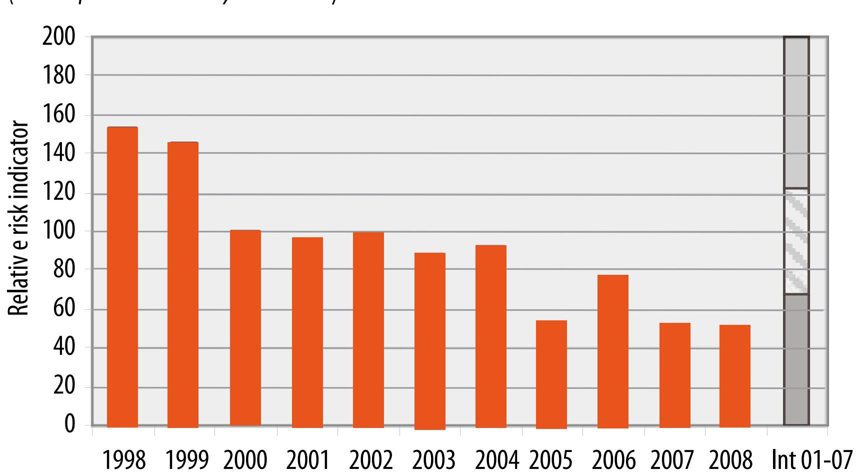


Figure 17 Total indicator, mobile units, normalised against manhours (Value put at 100 in year 2000)



increase. There is nevertheless an overall falling trend over the entire period.

The figure shows only the total value for the indicator. The values for mobile units are substantially influenced by well events and shallow gas blowouts in the period 2000-2002, and to an even greater extent, by structural damage. In 2007 and 2008 there were no incidents in the most serious category.

8. Status - Major Accidents Barriers

The reporting and analysis of barrier data have been continued with no significant adjustments from previous years, except for the introduction of two additional barriers: one expressing well status (Figure 13) and one the stability of mobile units. 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:

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

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

Figure 18 shows the relative fraction of failures for those barrier elements 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 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 constant level with minor variations. The exception concerns data from muster drills, where the total number of drills and the proportion meeting efficiency requirements (VSKTB) remain more or less unchanged from year to year. Those with the lowest fraction are consistently those with the most stringent efficiency requirements. The installations with a low proportion of drills meeting the requirements are the same from year to year.

Figure 18 Relative number of faults for selected barrier elements, 2008

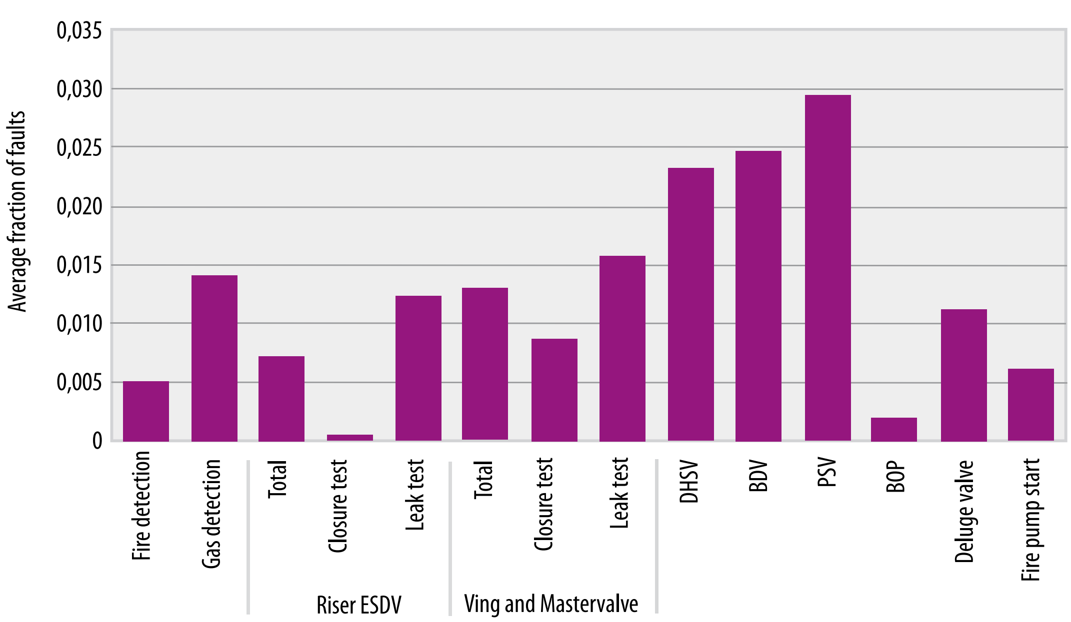
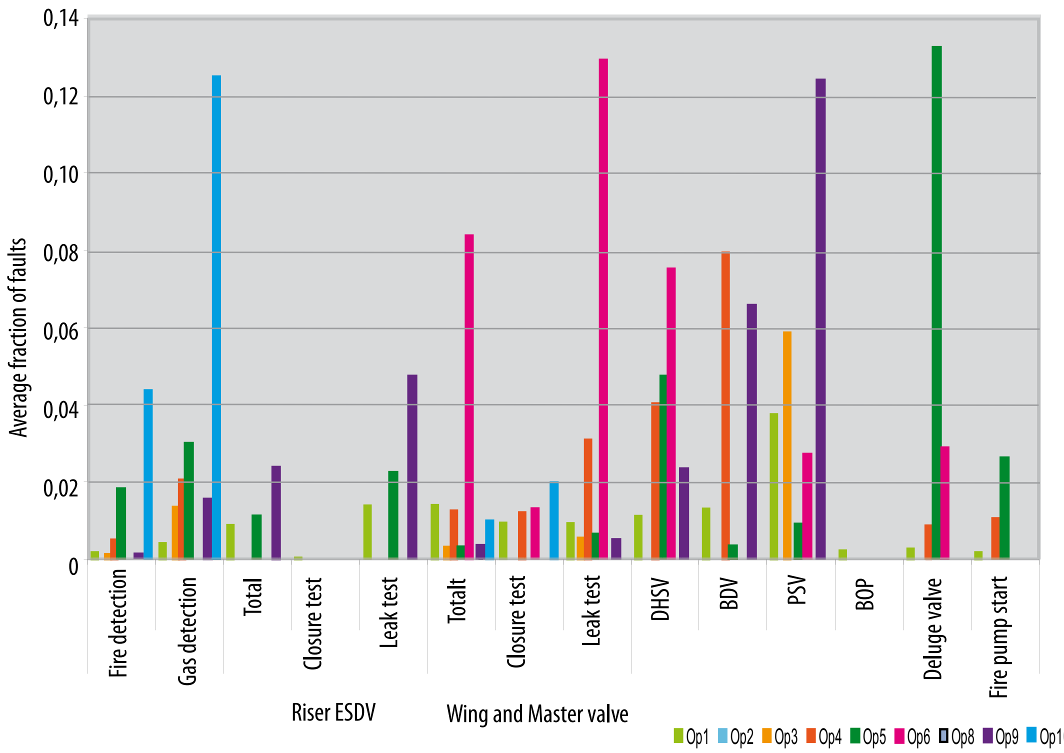


Figure 19 Total fraction of failures presented per barrier element for operators 1 to 10



The Main Report shows the difference between the mean fraction of failures (Figure 18), 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.

Those installations which over a period of time have consistently higher fractions of test failures for many barrier elements have been scrutinised in relation to the number of leaks over 0.1 kg/s on the same installations. A corresponding analysis was performed in 2007 and the results show a corresponding consistency in these two years (see the Summary Report for 2007).

Figure 19 shows the total fraction of failures per barrier element for the eight field operators which have reported test data in 2008. The figure shows that there is substantial variation in the fraction of failures between the different operators. This variation is due to a number of 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.
- Difference in the number of tests. Variation is normally largest in the case of barrier elements with relatively few tests.

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 19 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 20 shows an example of this comparison for tests of gas detectors. Each installation has been given a letter code and the figure shows the fraction of failures in 2008, the average fraction of failures in the period 2002-08 and the total number of tests performed in 2008. Most installations have an average of less than 0.02 but there are some installations with a fraction of failures up to 0.05. Three installations had a high fraction of failures in 2008, with more than 10% failures out of the number of tests.

8.2 Barriers relating to Marine Systems

In 2008 there was data acquisition for barrier elements relating to marine systems, for:

- Watertight doors
- Ballast system valves
- Anchoring system
  - o The number of situations where a brake has been knocked out
  - o The number of situations where the second brake has also failed
- 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.

Figure 20 Fraction of failures for gas detection

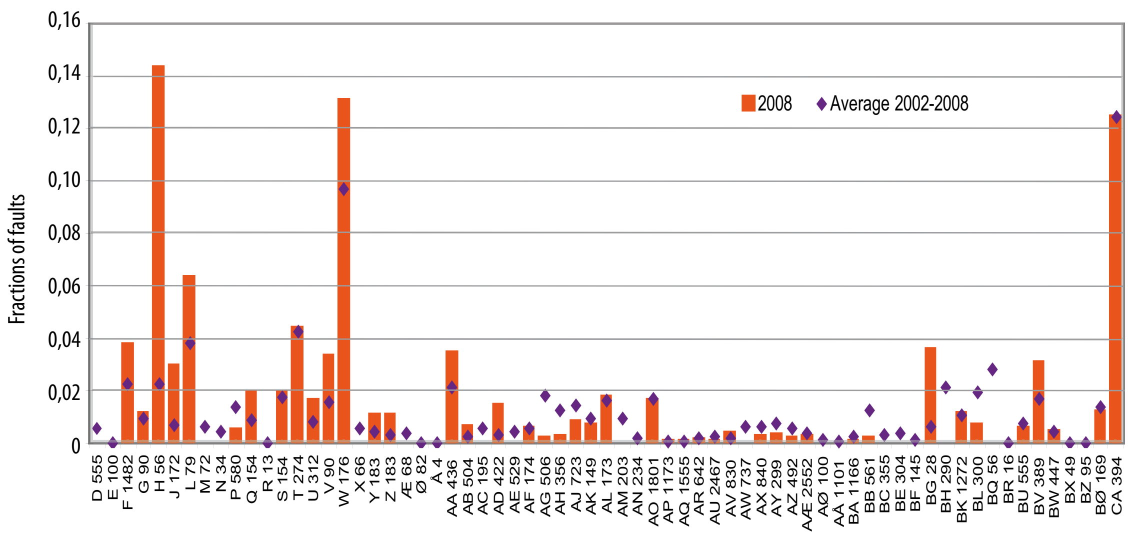
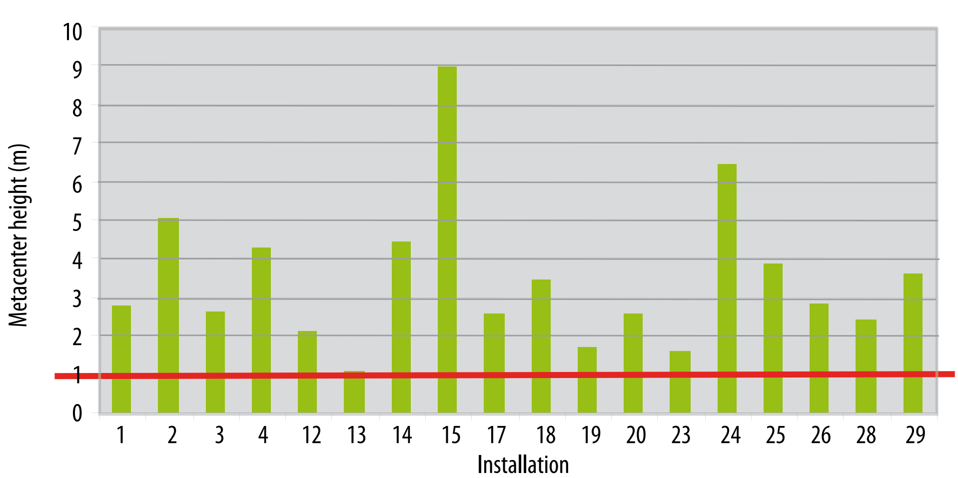


Figure 21 Metacentre heights (in metres) on mobile units (anonymized) for 31.12.2008 (The red line shows the minimum requirement for semi-submersibles)



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 for 2007 the fraction fell to under 0.5 %. The values for 2008 are on approximately the same level. No anchoring system failures were reported for these units. For mobile units the number of tests and number of failures vary from installation to installation. Average values are partly lower than for floating production units with respect to watertight doors and ballast system valves.

A new element in 2008 is that there was a request for metacentre height data (GM). This is the distance from the metacentre (M) to the centre of gravity (G) on the installation. When an installation tilts, the centre of buoyancy shifts horizontally. The point of intersection between a vertical line through the centre of buoyancy when the installation tilts and a line through the original centre of buoyancy with no tilting is the metacentre. 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 31.12.2008 was 3.36m, while the lowest was 1.06m. The minimum requirement for semi-submersibles stipulated in the Norwegian Maritime Directorate stability regulations is 1.0m for all operational conditions.

9. Status and Trends – Occupational Accidents resulting in Fatalities and Serious Injury

For 2008 PSA has registered 405 incidences of injury on petroleum installations on the Norwegian Continental Shelf that come under the criteria of death, absence continuing into the next shift or medical treatment. In 2007 there were 437 reported cases of injury. In 2008 no fatal accidents occurred in the PSA's area of authority on the Norwegian Continental Shelf. There were also 56 reported injuries classified as leisure time accidents and 163 injuries requiring first aid in 2008. By comparison, in 2007 there were 54 leisure time accidents and 165 injuries requiring first aid. Injuries in the leisure time and first aid categories are not included in figures and tables.

On production installations in the period 1998 to 2000 there were only slight changes in the total injury frequency, which has remained at a stable level since the early 1990s. From 2000 to 2004 a clear decline is seen, with a reduction from 26.4 to 11.3 occurrences of injury per million manhours in 2004. Since 2004 the total injury frequency has remained generally

Figure 22 Serious injuries to personnel on production installations related to manhours

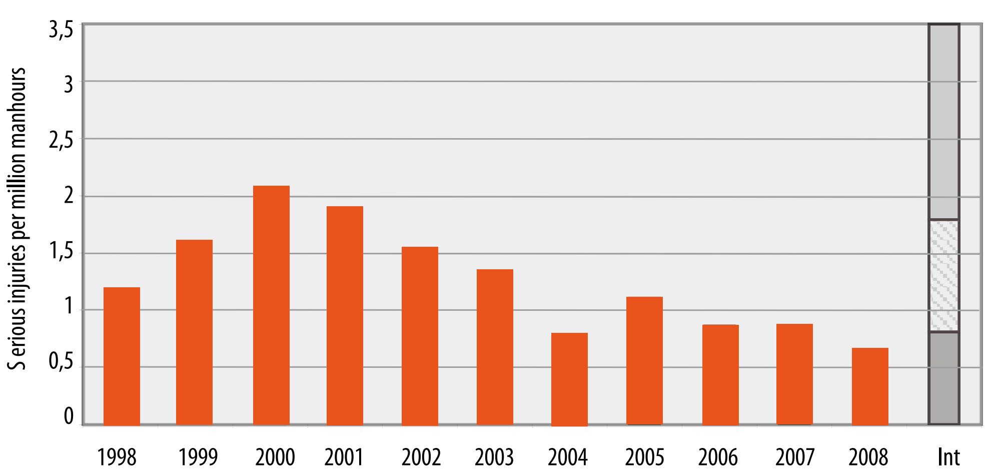
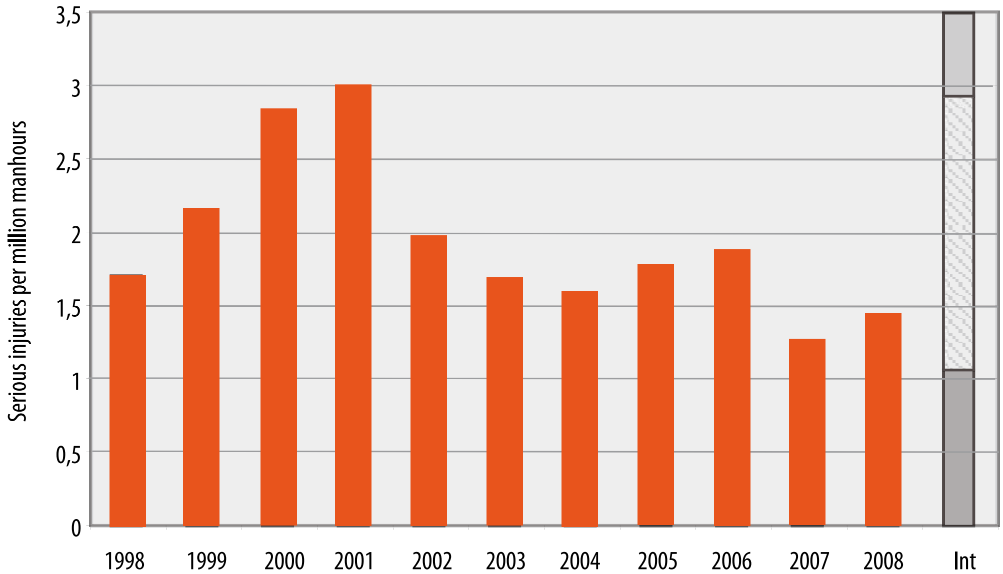


Figure 23 Serious injuries to personnel per million manhours, mobile units



unchanged and in 2008 lay at 10.7. In 2008 there were 312 occurrences of injury to personnel on production installations.

The picture for mobile units is similar to that for production installations, with only slight changes in the period 1997 to 2000, and frequency has remained generally stable since 1990. From 2001 frequency showed a consistent fall, from 33.7 to 11.1 in 2006. In 2007 there was again an increase in injury rate. However, the figures for 2008 point to a positive trend, with a reduction of 4.8 injuries per million manhours from 13.5 to 8.7 in 2008 and the figure is now below the level for production installations. In 2008 there were 92 occurrences of injury on mobile units as against 119 in 2007.

9.1 Serious Occupational Accidents, Production Installations

Figure 22 shows the frequency of serious injury to personnel per million manhours on production installations. The level of frequency shows a falling trend from 2000 to 2007. From 2007 to 2008 there was a change in frequency from 0.9 in 2007 to 0.7 in 2008. On production installations there were 19 cases of serious injury in 2008. In recent years the frequency of serious injuries on production installations shows a positive trend and this trend continues with the lowest ever frequency of injuries for 2008. The number of manhours has risen from 29.0 million to 29.1 million in 2008.

9.2 Serious Occupational Accidents, Mobile Units

The frequency in 2008 is 1.4 (see Figure 23) as against an average of 2.0 for the foregoing ten years. We have seen a marked decline in recent years from the peak in 2000 and 2001. From 2002 there were only slight changes in injury frequency. In 2008 however there has once again been an increase in injury frequency, from 1.3 in 2007 to 1.4 in 2008. This injury frequency still lies within the anticipated value based on the preceding 10 years in the lower part of the interval.

9.3 Comparison of Accident Statistics between the UK and the Norwegian Continental Shelf

PSA and the Health and Safety Executive (HSE) in the UK publish a half-yearly joint report containing a comparison of statistics for injuries to personnel on offshore installations. The classification criteria appeared at first to be almost identical but on closer scrutiny some differences in practice were discernible. With a view to improving the basis of comparison, we have had discussions with the UK authorities and have subsequently adopted common criteria for classification of serious injury to personnel and corresponding areas of activity.

The average frequency of cases resulting in death and serious injury for the period 2001 up to and including the first half of 2008 shows that there have been

0.96 injuries per million manhours on the Norwegian side and 1.03 on the UK Continental Shelf. The difference is not significant. On the other hand there is a greater difference in the frequency of fatal accidents in the same period. The average frequency of fatalities on the UK Continental Shelf is 2.9 per 100 million manhours against 1.2 on the Norwegian Continental Shelf, this difference being significant. On the UK Continental Shelf there were 11 fatalities in the period in question against 3 on the Norwegian Continental Shelf.

The figures indicate that there is probably considerable underreporting of serious injuries on the UK Continental Shelf. This accords with HSE's own view.

10. Risk Indicators – Noise and Chemical Work Environment

Risk indicators for noise and chemical work environment were developed in cooperation with expert personnel from the industry. Importance was attached to the need for the indicators to reveal risk factors as early as possible in the causal chain leading to occupational accident or illness.

With few exceptions, data have been registered from all installations on the Norwegian Continental Shelf, for both mobile units and production installations. In regard to noise, the data set shows that there is common understan¬ding of the reporting criteria and the indicator appears to give a meaningful picture of the situation. It also seems to be sensitive to change. For the chemical work environment the situation is different. Some of the reporting reflects divergent understanding of the reporting criteria. This means that the indicator is not as robust as one might wish. Changes have therefore been introduced in reporting procedure for 2008.

Comments from the companies have been generally positive. The indicators have attracted commitment and management attention and an improvement is noted in the prioritisation of risk reduction. In estab-

Figure 24 Average exposure to noise by job category and installation type, 2008

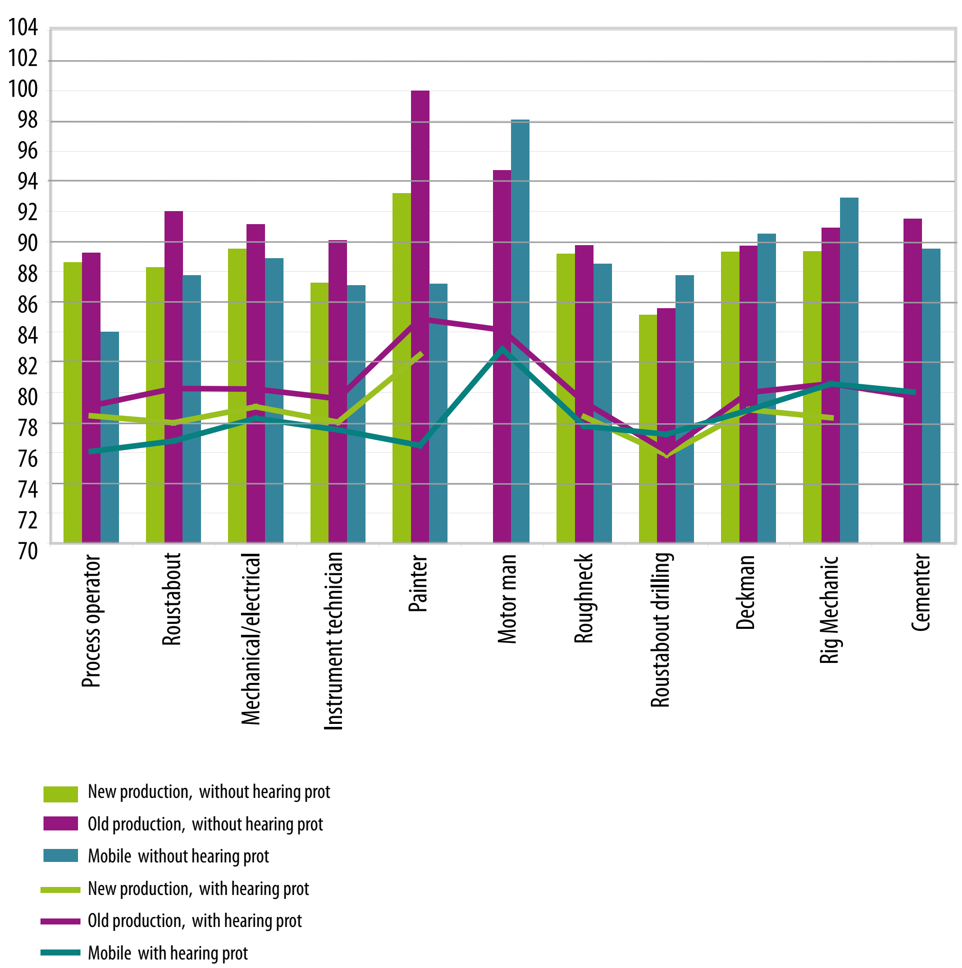
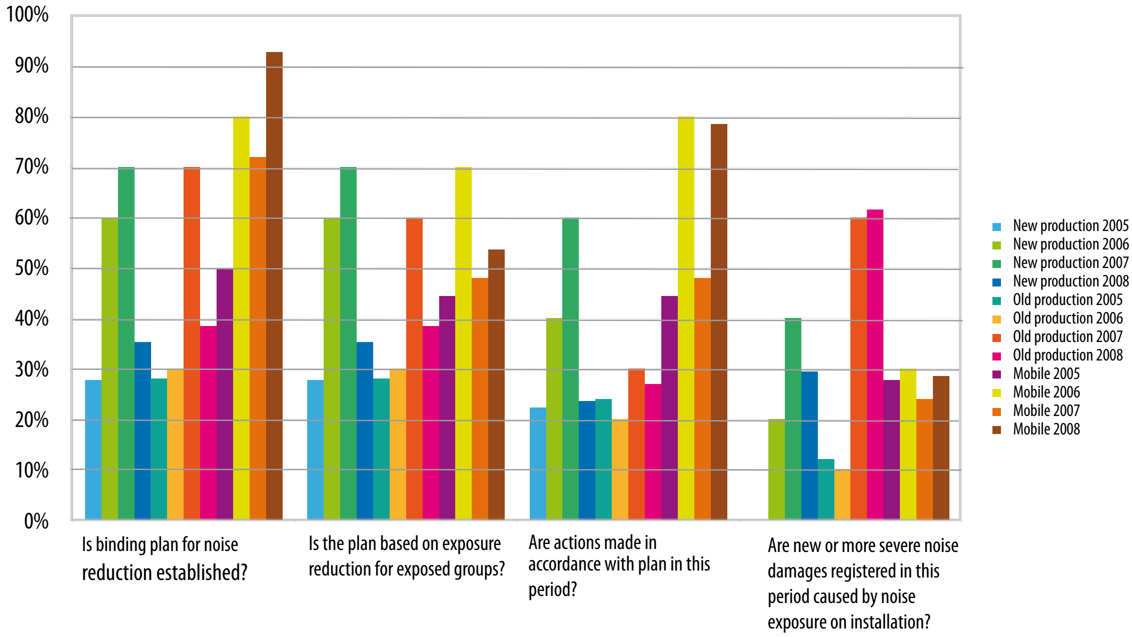


Figure 25 Planned risk reducing measures



lishing the indicators, it was an important aim that they should support good processes in the companies. There is a high level of activity in the industry directed towards the development and implementation of methods and tools for risk assessment and management in relation to noise and the chemical work environment, and there are many good examples in the industry of comprehensive improvement projects.

It is important to emphasise that the indicators represent a collection of a rough and simplified set of data aimed at providing companies with a tool allowing them to monitor trends and prioritise improvement measures at different levels – installation, company, industry and authority. This set of basic data in itself is not enough to satisfy statutory requirements in relation to noise and the chemical work environment in individual companies.

10.1 Noise with Potential for Impairing Hearing

The indicator for noise exposure covers 11 pre-defined job categories. Data have been reported for a total of 2400 persons, an increase from 2007 when reporting covered 1854 persons. The average noise indicator for the 2400 persons included in the survey is 90.2. This is a slight improvement from the 2007 level of 90.4. The distribution over different job categories and groups of installations is shown in Figure 24 (further details in the Main Report, PSA, 2009a). The results show an improvement on 36 of total 71 installations, an increase in relation to 2007. The figures show a marked improvement for 3 new installations in particular, with a noise reduction of between 12.9 dBA and 17 dBA.

If we assume that the noise indicator reflects real noise exposure, most job categories covered by this survey have a level of noise exposure exceeding 83 dBA which is the limit stipulated in the Facilities Regulations Section 22. However, if we take into account the use of hearing protection as reported by the companies, the majority of job categories are seen to have a level of noise exposure within the required limit. Even if we apply a conservative estimate for the noise suppression effect of the hearing protection, this does not mean that the situation is satisfactory. Hearing protection has clear limitations as a preventive measure. Persistently high reporting of hearing damage indicates that this is not an effective barrier. The average noise indicator with hearing protection for the 2400 persons included in the study is 79.2, the same level as in 2007.

Uncertainty has been calculated in the results. Depending on job category, five per cent of persons will have a level of noise exposure up to 10 dBA higher than that indicated by the given average values. Uncertainty is typically largest for categories such as electricians and mechanics, who have widely varying exposure to noise.

The noise indicator for the job categories painter and motor man is markedly higher than for other groups and for these categories the noise indicator including hearing protection is also relatively high.

Only eleven installations have reported the implementation of technical measures which together have led to a reduction in noise exposure by respectively 1dB, six installations with a reduction of 3 dB, two installations with a reduction of 5 dB and one installation with a reduction of 8 dB for certain job categories.

Reporting confirms that a number of companies have formalised and implemented schemes for limiting working hours. Of 71 installations there are only 11 which have not introduced such schemes for certain groups, these being mobile units.

Despite the fact that the indicators point to high exposure, some installations have still not established plans for risk reduction measures, cf. Figure 25. This picture shows a more negative trend for production installations than in 2007. For mobile units a change is noted from previous years, the picture now taking a markedly positive direction with 90 % of mobile units having established plans for risk reduction. The industry can be slow to implement planned measures, particularly so in the case of new production installations. In the case of mobile units, however, approximately 80 % of planned measures have been effectuated. For older production installations and mobile units, some new or aggravated cases of hearing damage have been registered in the period.

There were 623 cases of noise-related injury reported to the Petroleum Safety Authority in 2008. This is at the same high level as for 2007 (595). The high incidence of noise-related hearing damage is partly due to changes in reporting criteria. On the basis of previous results, half the cases of noise-related injury can be assumed to be due to occupational exposure. If we also take into account that there is a substantial degree of underreporting, particularly in the contractor segment of the industry, and that there are probably selection mechanisms at work serving to conceal cases of injury, we appear to be facing incidences of injury on a relatively large scale.

Taking the picture as a whole, it is clear that large categories of personnel are exposed to excessive noise and thus run a considerable risk of developing hearing impairments. The PSA's experience through contact with the industry, report-processing and audits confirm the impression given by the noise indicator. If we wish to achieve telling reductions in risk, companies must show greater willingness and ability to get results and learn from successful measures.

10.2 Chemical work environment

From 2008, there has been a change in the set of indicators for the chemical work environment. Reporting of the number of exposure measurements was attempted in 2007 but a check of the companies' reporting basis led to the conclusion that there is too high a degree of uncertainty with respect to how far the collected data are comparable and how good an expression of risk the measurements performed can give. In 2008 the PSA asked the representatives in the Safety Forum for their comments and recommendations for changes aimed at making the indicator more robust. Many of them pointed to the need to establish an indicator which is a direct measurement of the health risk from chemicals. Following their recommendations, a method was developed based on the exposure matrix in NORSOK S-002 rev.4 Annex G. Four job categories were chosen to report data on the those incidences of highest exposure, discounting the use of personal protective equipment.

In 2008, data were reported from 41 production installations and fields and 27 mobile units. Each cell in the matrix has been allocated a risk value corresponding to the product of the numerical values (1-5) for the category of health risk (inherent properties) and exposure category (1-6), in which the highest possible exposure gives a risk value of 20 and the lowest exposure is 1.

The indicator for the chemical spectrum's hazard profile has been retained unchanged. This is given by the number of chemicals in circulation per installation 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 occurrence and use of potentially hazard-

Figure 26 Risk estimation 2008, production installations

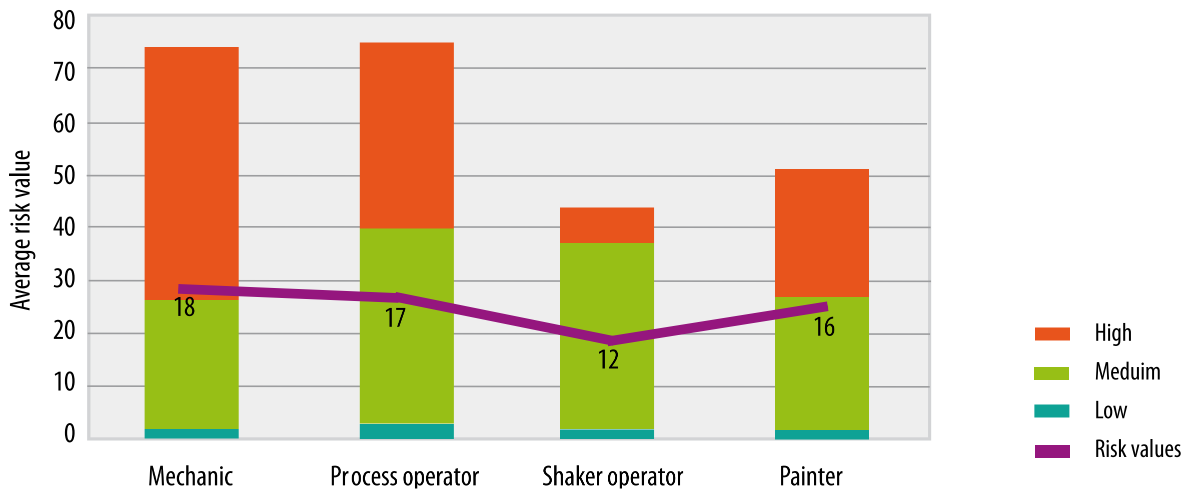
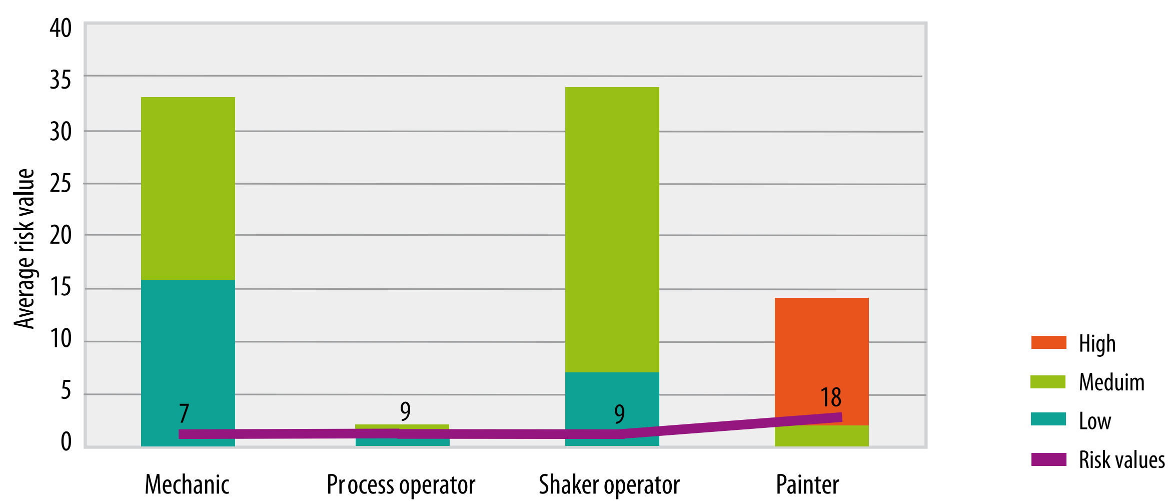


Figure 27 Risk estimation 2008, mobile units



ous chemicals. It is a recognised scientific argument that the probability of health-hazardous exposure increases with the number of harmful chemicals in use. The indicator is supplemented by data on the number of chemical substitutions effectuated during the past year and bringing health benefits. The indicator for 2008 showed little change from 2007 and the substitution of hazardous chemicals was at a rather lower level than in 2007.

The new indicator tested in 2008 is based on reporting of actual exposure data for defined job categories. No account is taken of the use of personal protective equipment because it is considered to be a weak barrier against a potentially serious consequence. It is worth noting that the centre of gravity lies in the red area for production installations, while for mobile units it lies considerably lower. The difference in evaluation between fixed installations and mobile units is probably greater than the actual difference in risk would suggest.

For mechanics the average risk value is 18, representing a risk assessment in the red area. For the other job categories it is slightly lower. On mobile units, painters are assessed to have an average risk value of 18 while for the other job categories the value is substantially lower.

In the case of process operators, exposure to benzene is the dominating feature in the risk picture while for shaker operators oil mist and oil vapour are the most frequently-occurring factors. In the region of 30 percent of assessments are supported by measurements. It is a matter of basic concern that a high level of risk for potentially serious health effects is reported where

personal protective equipment is the only means of protection.
Experience from working with the risk indicator for the chemical work environment shows that it is difficult to arrive at a reporting basis on which there is general consensus. Although there is no concrete verification, this is probably also true of the new indicator. The criteria give room for discretion and there is probably only one way of improving this: through active inter-company cooperation and calibration enabling companies to arrive at a common interpretation of the criteria and uniform reporting practice.

Figure 26 and Figure 27 show the job categories distributed by high, medium and low risk combined with the average risk value per category for production installations and mobile units.

11. Other Indicators

11.1 DFU21 Falling Object

There were 221 events reported to the present study for 2008, a reduction from the average of 250 for the period 2002-08. In the figures given to PSA, 150 events were notified for 2008, against an average of 110 reported events in the period 1997-2008. There has been a fall of approximately 10 % from 2007 but over a period of 5-6 years there is still a marked increase, probably due to the sustained focus on falling object events over a number of years and the fact that no lower limit has been set for reportable events. The figures are not comparable and cannot be used to determine trends.

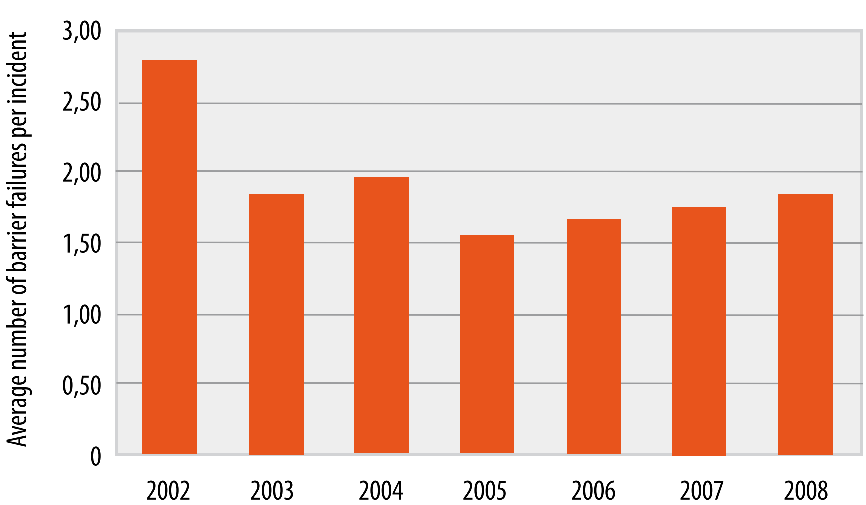
A falling object can result in injury to personnel, material damage, production stop or a combination of these. In 2002 there were two fatalities (17.4.2002 on Byford Dolphin and 1.11.2002 on Gyda) but no cases of fatality since 2002. The number of injuries has varied between two and 18 per year, with an average of 10 injuries a year. Seven cases of injury were reported in 2008. Data have been reported for two indicators from and including 2002:

- The frequency of falling objects for different work processes (drilling, crane operations, process and other)
- The frequency of falling objects for different energy classes (indicator for showing the potential of a falling object for damage to equipment and structures and injury to personnel).

There has been an evaluation of barriers relating to falling objects, based on investigation reports. The terminology often used in relation to barriers etc. in these contexts differs a little from terminology used in other connections. In Section 8 we distinguish between barriers, barrier functions, barrier elements and influencing factors. In official investigations it is common to use a single term: "barrier", with the following wide interpretation: "all systematic, physical and administrative forms of protection found in the organisation and the individual workplace to prevent the occurrence of, or to limit the consequences of, failures and erroneous actions". Examples of barriers using this interpretation are rules and safety systems, procedures, guidelines etc.

With a view to identifying barrier failures, we have studied the events investigated. Just over 60 % of falling object events have been investigated in the last four years. An overview of barrier failures in

Figure 28 Overview of barrier failures in relation to DFU21 falling object, 2002-2008



the period 2002-2008 is shown in Figure 28. The dominant causes of events in 2008 are:

- Working practice/individual factor
- Company management/platform organisation
- Work environment
- Ergonomics – poor technique

"Working practice/individual factor" covers failure to follow procedure or deviation from procedure, lack of preparation and individual checking, and individual factors such as fatigue, illness, motivation etc. "Company management/platform organisation" refers to e.g. lack of maintenance programmes, quality assurance programmes and test programmes, lack of experience transfer or risk analysis, etc. "Work environment" refers to inadequate lighting or poor visibility, inadequate cleaning, cramped or stressful working conditions, uncomfortable temperature or humidity, strong wind or high waves or high sound level. In 2008, as in 2007, many events were reported giving strong wind as a cause of the occurrence.

"Ergonomics – poor technique" refers to poor (written) instructions/lack of instructions, poor marking/lack of marking of components, poor accessibility, poor ergonomics or design. The highest percentage of events in this category can be related to technical design.

11.2 Other DFUs

In the Main Report we present data events reported to the PSA, and for the following remaining DFUs, which do not have major accident potential:

- DFU10 Damage to subsea production facilities/pipeline systems/diving equipment caused by fishing gear
- DFU13 Man overboard
- DFU16 Total blackout
- DFU18 Diving accident
- DFU19 H2S release

12. Definitions and Abbreviations

12.1 Definitions

See Subsections 1.9.1 - 1.9.3 and 5.2 in the Main Report.

12.2 Abbreviations

For a detailed list of abbreviations see PSA, 2009a: Risk level in the petroleum industry, Norwegian Continental Shelf, main report, 2008 23.4.2009. The most important abbreviations used in this report are as follows:

CODAM	Database for damage to structures and subsea installations
DDRS/CDRS	Database for drilling and well operations
DFU	Defined situations of hazard and accident
GM	Metacentre height
HES	Health, environment and safety
MTO	Man, Technology and Organisation
NPD	The Norwegian Petroleum Directorate
PSA	The Petroleum Safety Authority
SfS	Working Together for Safety
SFT	The Norwegian Pollution Control Authority
VSKTB	The activity's specific requirements for prepared ness (efficiency requirements)

13. References

For a detailed reference list, see the Main reports:

PSA, 2009a. Risk level in the petroleum industry, Norwegian Continental Shelf, main report, 2008 (In Norwegian), PSA 09-01, 23.4.2009

PSA, 2009b. Risk level in the petroleum industry, Land based facilities, 2008 (In Norwegian), PSA 09-04, 23.4.2009

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