CSB Public Hearing

Safety Performance Indicators

Houston, TX - Hyatt Regency Hotel, July 23 – 24, 2012

Regulatory, Stakeholder, and Public Interest Groups Panel – discussion of the use of indicators to improve safety as seen by the regulator and entities with safety/environmental concerns

Trends in Risk Level Norwegian Petroleum Activity (RNNP)

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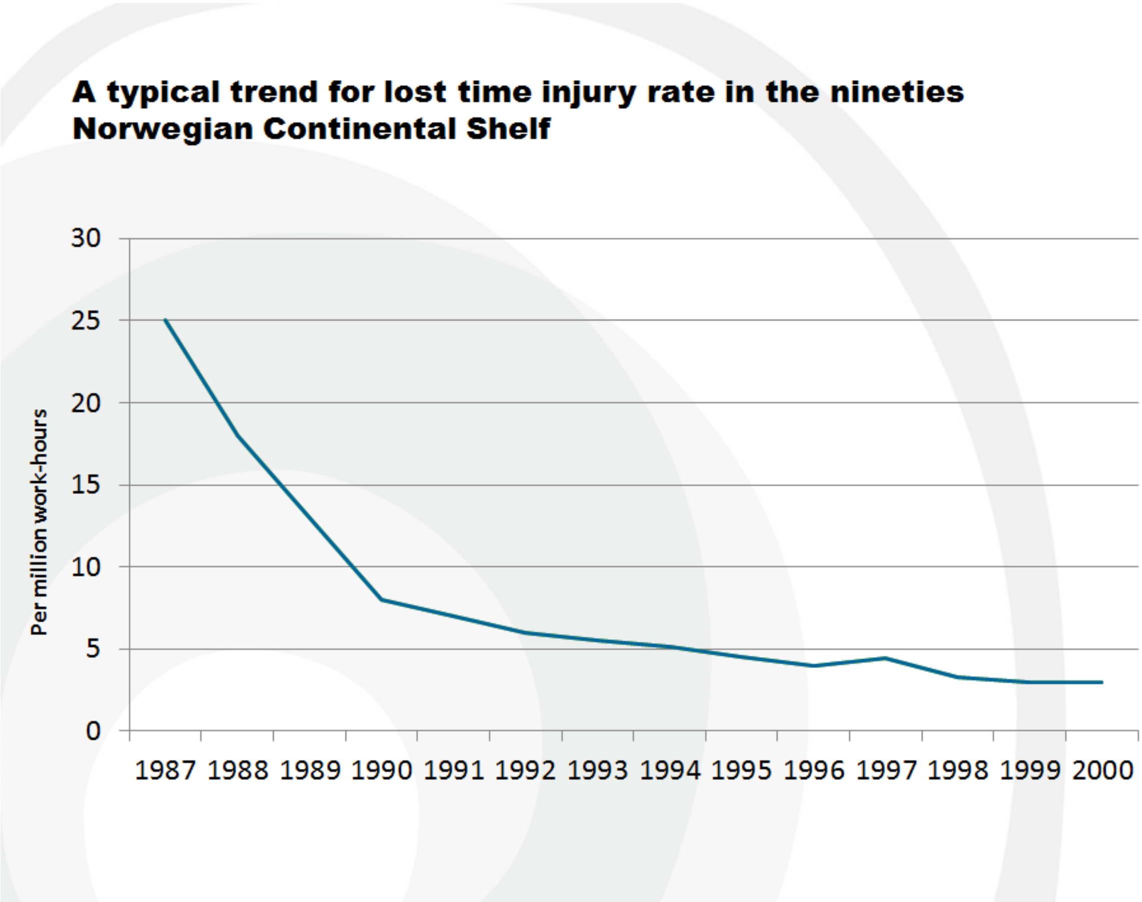
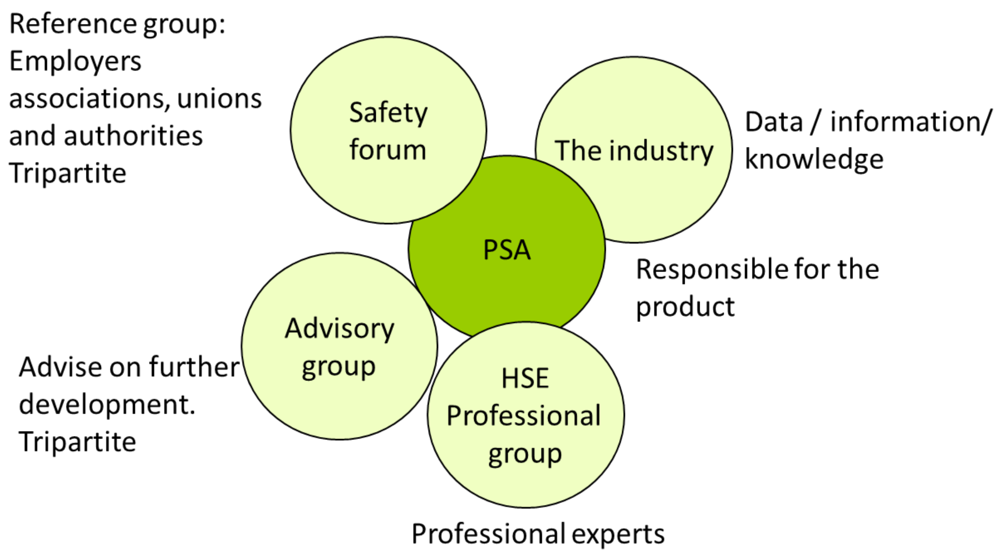
Brief about the background for establishing RNNP

In the late 1990s there was a widespread disagreement between the parties in the offshore petroleum industry regarding the trend in risk level at the Norwegian Continental Shelf (NCS). Unions claimed that cuts in workforce and demands for simpler and faster project execution had resulted in an increase in the risk of serious accidents. The oil companies and their organization at the other hand claimed, mainly based on lost time injury statistics, that safety never had been better.



We as a safety authority lacked a basis for knowing which way the risk trend actually moved, and we had insufficient grounds to prioritize our efforts and challenge the industry in the areas where they had to improve their performance.



The Trend in Risk Level Project (RNNP)[1] was initiated in 1999/2000 to develop and utilize measuring tools which should illustrate the development in the risk level on the Norwegian shelf. Further it should provide a basis for prioritizing of safety and work environment efforts in the industry and the prioritizing of PSA supervisory activities. The project is now converted to an annual activity, has been carried out twelve times and methods and indicators have been adjusted and improved every year. Still, main emphasis has been that trends should be possible to track back in time.

It was important to establish a description of the risk level the parties in the industry could agree upon was sufficiently reliable. Therefore, the methodology used in RNNP was and still is developed in close cooperation with the collaborating parties. RNNP is managed by PSA, who is responsible for the product.

The project is supported by highly qualified safety experts from national academic institutions, from the E&P companies and other well-known experts within their respective field.

The companies' participation is essential for the collecting of data with good quality, and they participate in developing methods and indicators - useful both for the company's own safety management and for the industry as a whole through RNNP.

The tripartite cooperation in Safety Forum[2] and the advisory group create a sound arena for discussion of results and the development in the risk level. Thereby agreement is developed on important aspects that have to be prioritized and addressed by the different parties. One could also argue that the tripartite cooperation give the indicators more authority.

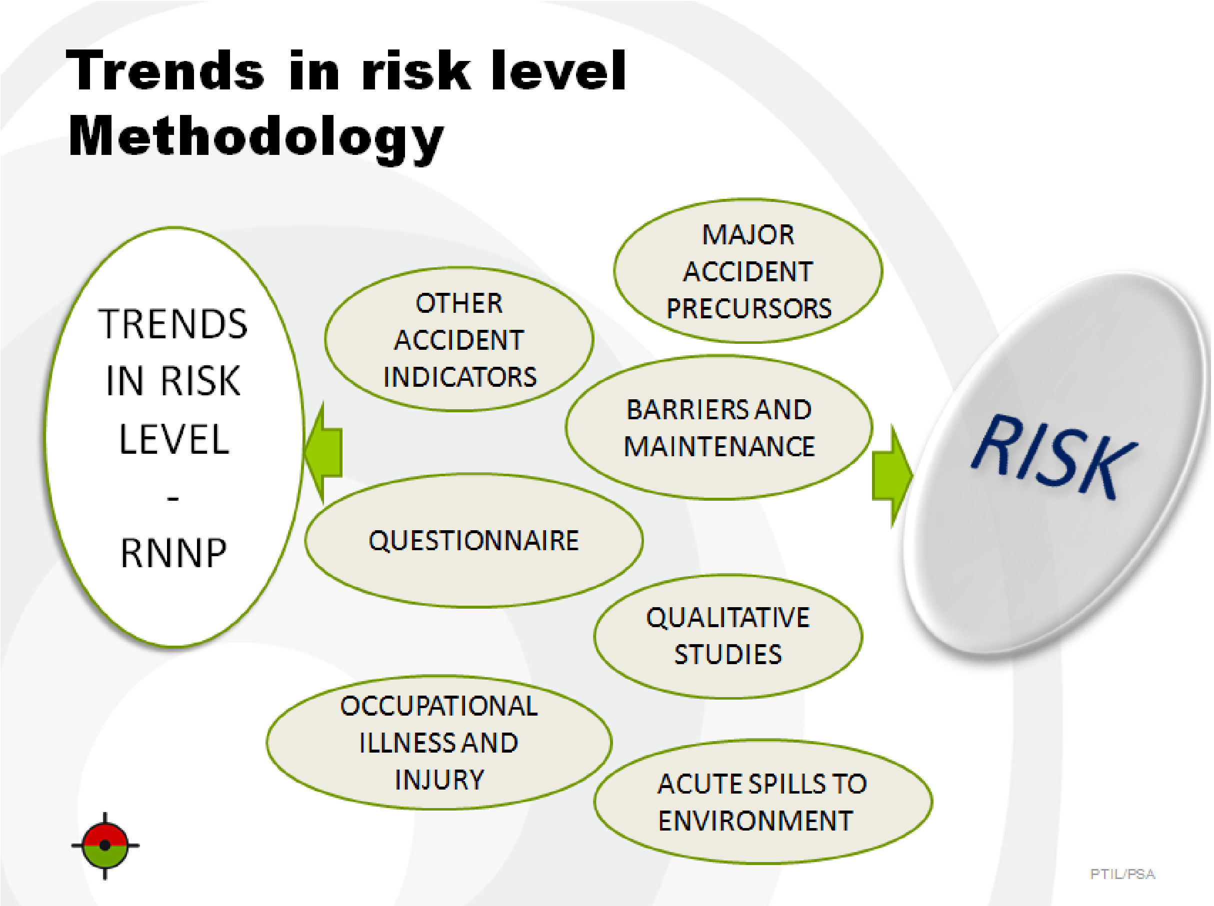
Methodology used in RNNP

A key aspect of the RNNP approach is to identify relevant indicators reflecting different aspects of risk relevant for the petroleum industry. Safety performance indicators may be of very different

[1] http://www.ptil.no/trends-in-risk-level/category155.html
[2] The Safety Forum is the central arena for cooperation among the parties in the industry and the authorities as regards health, safety and environment in the petroleum activities on the Norwegian shelf and on land. More about Safety Forum: http://www.ptil.no/safety-forum/category167.html

kinds. We should also always have in mind though that an indicator is an indicator of something, not the phenomena itself. Lead and lag indicators is a common used concept pair where leading indicators shall provide us with information regarding the current situation which can affect future performance, while lag indicators of safety usually refer to accidents, injuries or fatality rates. Both leading and lagging indicators are developed and used in RNNP.

Analysis is based on the triangulation principle – that is to use different methods, indicators and tools to measure the same phenomena – in this case risk and the development of trends.



We can in principle split our indicators and tools into seven broad categories:

1. MAJOR ACCIDENT precursors: This is a central focus area in our work. Major accident in this context is typical an accident with the potential to generate multiple fatalities. I will come back to a few of these indicators later.

2. OTHER ACCIDENT INDICATORS: Accidents with lesser potential, e.g. total loss of power, falling object, serious occupational injuries and fatalities. Mainly lagging indicators.

3. BARRIERS and MAINTENANCE: These are leading indicators that provide us with information about robustness in relation to capacity for withstanding potential events. Focus here is on barrier availability, especially in relation to consequence reducing barriers performance in relation to loss of containment. The maintenance indicators focus on maintenance management, e.g. lag in risk classification of equipment and backlog in preventive maintenance for safety critical equipment.

4. QUESTIONNAIRE – we have now, since 2001, carried out a comprehensive self-completion survey distributed to all workers on offshore petroleum installations. Since 2007 employees on land facilities were also included[3]. Even though the questionnaire has been developed, the core questions remain, giving us the opportunity to establish trends. The focus areas for the questionnaire are:

    Safety climate – perception of safety management, prioritizing of safety and empowerment of the organization to act adequately in relation to risk

    Working environment conditions, perceived risk and health issues

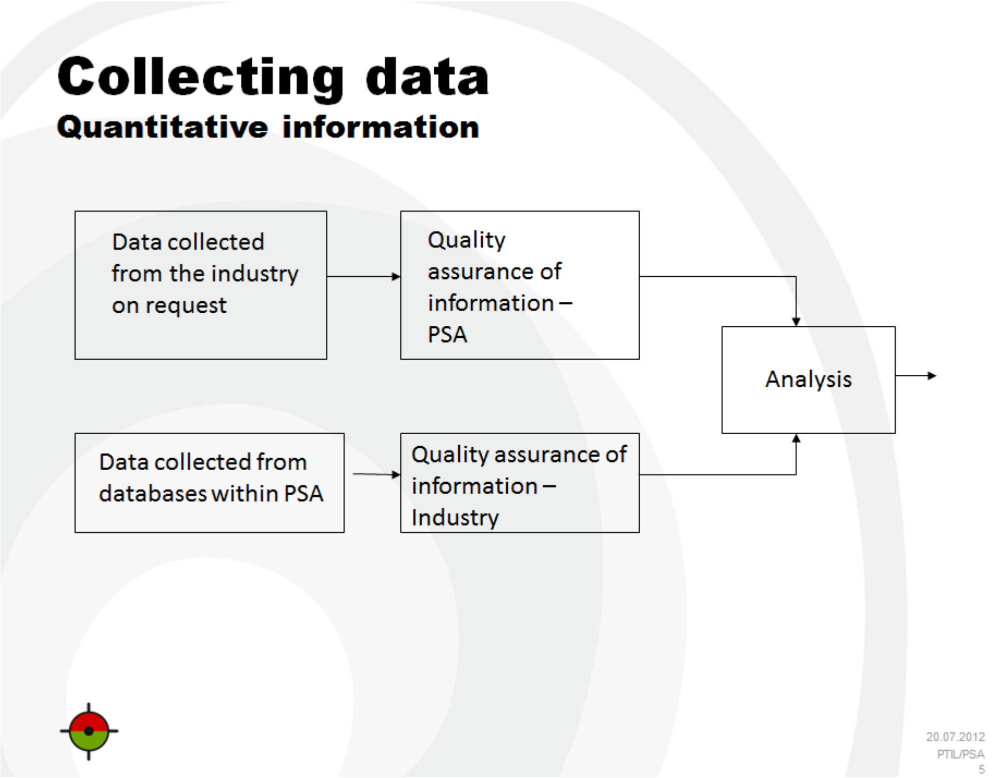
5. QUALITATIVE STUDIES – these studies are based on social scientific principles. The purpose of these studies is to obtain more in depth knowledge about certain challenging issues that has been identified from other indicators or measurements. For instance; based on a negative trend in well incidents in the period 2008 to 2010, and the Macondo blowout in 2010, we carried out a study on causes and measures related to well control incidents in Norwegian petroleum activities in 2011[4].
6. OCCUPATIONAL ILLNES AND INJURY – Indicators, mostly leading, are developed for chemical working environment, noise related injury and physical working environment.
7. ACUTE SPILLS TO ENVIRONMENT – In 2010, new leading and lagging indicators are established on acute spills to environment on the NCS, [5]

Results and information from these tools and indicators are used to synthesize conclusions related to RNNP.

INPUT

Indicators need data. I have already mentioned questionnaire data. Qualitative data comes from various sources – often interviews, fieldwork or by analyzing and systemizing written material, e.g. incident and investigation reports.

[3] Response rate varies between 30 and 50%. The number of responses offshore was 8032 in 2011 and the respondents covering the various groups of employees in a satisfactory manner and is sufficient to permit statistical analysis – also on group level.
[4] http://www.ptil.no/news/more-well-control-incidents-should-be-investigated-article8657-79.html
[5] http://www.ptil.no/news/rnnp-report-risk-development-for-acute-spills-on-the-norwegian-continental-shelf-2001-2010-article8101-79.html

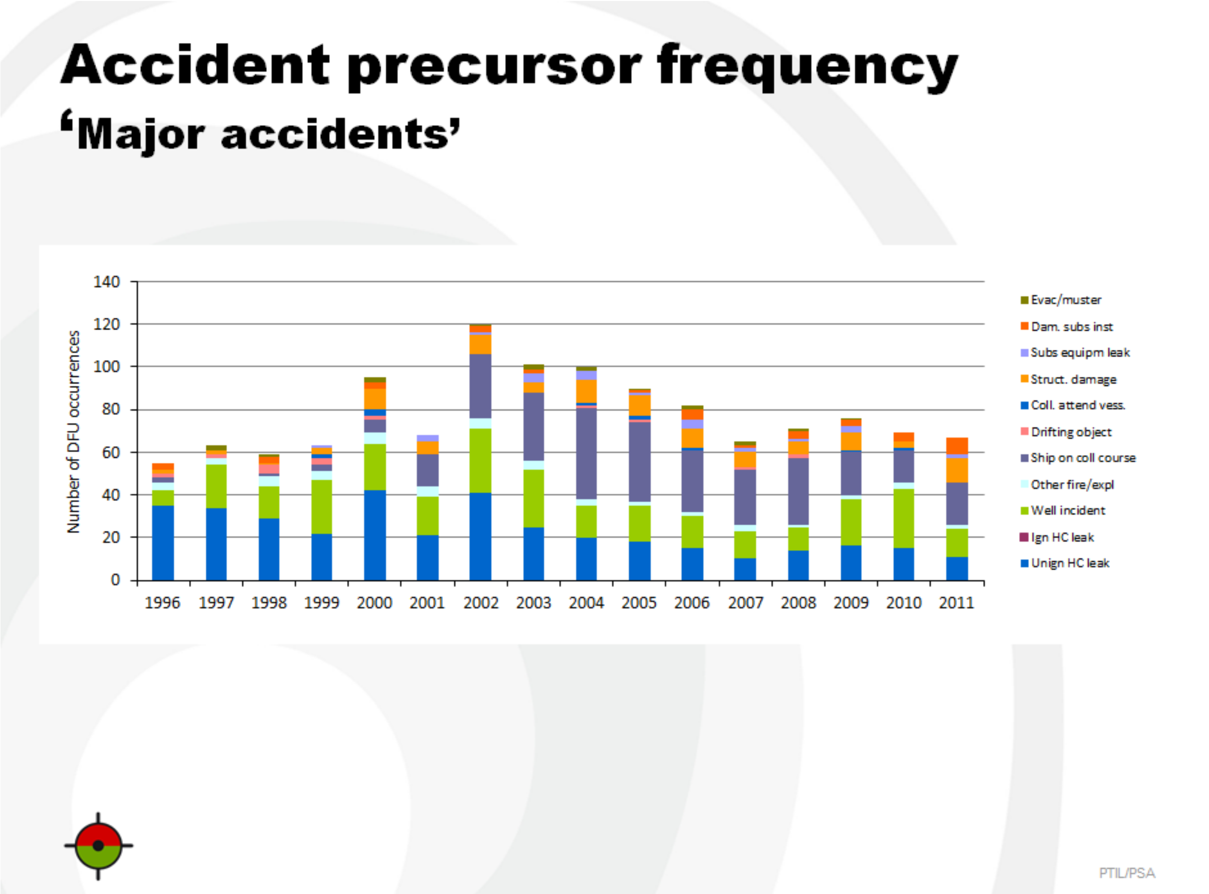


The quantitative information is collected from two main sources. 1) Directly from the industry upon request, typically a letter with a spreadsheet once or twice a year. 2) The other source is our own internal databases containing information which the companies are obligated by regulatory requirements to send in – for instance incident data, working hours and daily reports on drilling and well activities.

The dataset is then quality assured by PSA and in the companies, at least where practical, by swopping data in order to check each other's data. This is typical not on dataset level, but more on specific incidents and data abnormalities.

How can effective process safety performance indicators be identified and developed?

Process safety performance indicators should constitute observable measures that provide relevant insight to improve process safety.



In RNNP we have identified and used at set of indicators related to major accidents. Most of these indicators are well known and in use in the industry as requisite for risk management. In RNNP we have, together with the industry, identified common criteria for different defined situation of hazards. For major accident we have 10 indicators.

This figure shows the frequency of these major accident precursors in the period 1996 to 2011. It does not show the risk because the different situation of hazards covers a wide range of risk potentials and because within each category two incidents also can have very different risk potential, e.g. an unignited gas leak will have different risk potential depending whether it is 0.1 kg per second or 10 kg per second.

Later on I will give you an example on how these accident indicators are used to estimate the trend in risk and go more into details regarding the well incident precursors.

The figure shows mainly that the frequency fluctuates, but on average 75 per year is sufficient for statistical analysis both within each of the different categories and in total.

What are the critical characteristics of effective indicators?

Based on the PSA experience there are a few critical issues that are important in relation to developing indicators:

- The indicator must map the phenomena in question

- The indicator must be sensitive to changes in the measured phenomena, i.e. positive and negative changes in the real world should be reflected in the indicator.
- The amount of data/information must suit the intended use (e.g. counting major accidents won't give any statistical foundation, counting precursors to major accidents could give enough data)
- The more intuitive the indicator is – the better, especially in relation to communication
- The indicator should be meaningful and of importance for the companies in their work for improving safety

Do leading indicators provide more preventative value than lagging indicators?

Major accidents are fortunately relatively rare, so lagging indicators based on the number of major accident would provide insufficient information when it comes to prevention. Our work on leading indicators, i.e. establishing precursors of major accidents, has shown useful to map relevant and specific risks in order to direct measures towards them, and, hence, to prevent accidents from occurring. Since we are able to monitor the development in risk levels from year to year, it also becomes possible to evaluate whether implemented improvement projects are yielding results, and it enables both the PSA and the industrial actors to define what areas to focus next. So, it helps both us and the industry in prioritizing the most important risk areas. We find it absolutely necessary to use leading indicators when it comes to prevention of major accidents. However, there is also much learning through the investigation of major accidents.

How do we normalize or standardize leading indicators so that comparisons can be made across companies?

Different activity level measures are used to normalize both leading (and lagging) indicators. Examples of such normalization measures are: Number of production installations, number of mobile drilling units, number of work hours, produced volumes, length of pipelines and number of exploration and production wells. The normalization measure used will depend on the nature of the indicator. The activity level measures make it possible to compare from year to year, across companies and different groups of companies.

When it comes to the total risk indicators for potential loss of lives, we use the number of work hours to normalize the indicator across the different precursors.

Well control incidents – an example of a leading indicator for blowout

As an example of one of the ten major accident precursors, I shall use the well control incidents. The well control incident precursors are leading indicators for the major accident "Blowout". With regards to this indicator, we have defined a set of criteria for reporting well control incidents in RNNP. Until 2011 we have collected well control incidents data related to drilling and completion operations. These criteria are further developed in collaboration with OLF's Drilling Managers Forum and will from 2012 also cover well intervention operations. The RNNP criteria are adopted by a new OLF guideline[6] and I will use the categorization matrix from this guideline as an example of leading indicators.

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[6] http://www.olf.no/en/Publica/Guidelines/BoringDrilling/135---OLF-recommended-guidelines-for-classification-and-categorisation-of-well-control-incidents/

OLF recommended guidelines for classification and categorization of well control incidents

No.: 135 Established: 30.05.12 Revision no: 0 Date revised: Page: 11

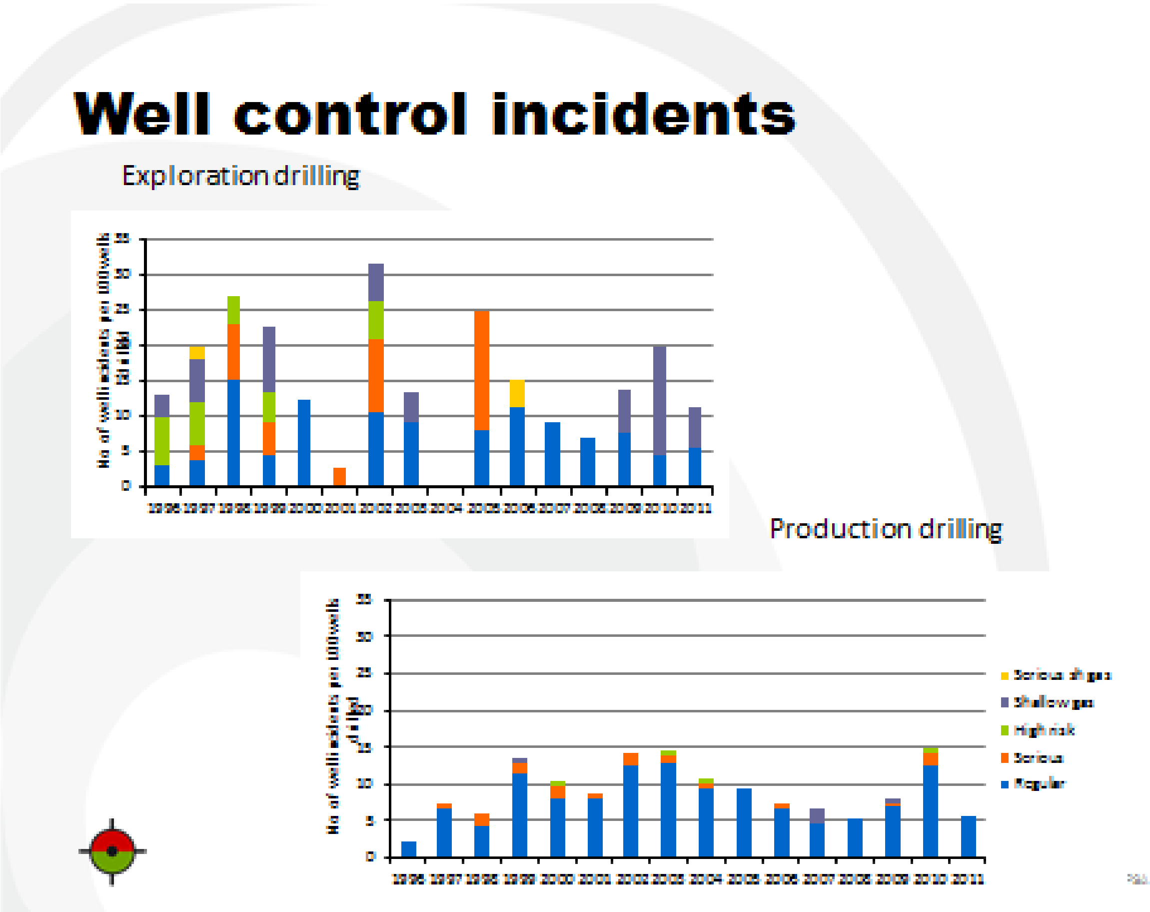
App B Categorisation and classification matrix for well control incidents

Matrix for categorization and classification of well control incidents
Drilling and Completion operations

Degree of seriousness	RNNP	Drilling and completion	Guidance
Level 1- Red **Critical well control incidents with high risk for personnel, environment and facility**	N/A*	**1. Blowout**	1. Blowout to environment or facility including underground blow out. Failure of primary and secondary barriers.
	3	**2. High risk HC influx**	2. Failure of primary well barrier. Activation of the secondary well barrier in critical kill operations with high risk of blowout.
	5	**3. Serious shallow gas flow**	3. Shallow gas incident with high risk for personnel, integrity or stability of the installation.
	New category	**4. Serious shallow water flow**	4. Shallow water flow with high risk for stability of an installation (jack-up, fixed installation or template)
Level 2 – Yellow Serious well control incidents	2	**1. Medium Risk HC influx**	1. Influx above kick margin, but possible to regain barrier with standard kill procedure.
	2	**2. Fluid barrier lost**	2. Loss situation without being able to maintain the hydrostatic pressure in the well and closure of BOP with pressure underneath.
	4	**3. Medium shallow gas flow**	3. Shallow gas incident with unsuccessful dynamic kill operations. Gas flowing to seabed or gas handled on installation.
Level 3 – Green Regular well control incidents	1	**1. Low risk HC kick or water kick**	1. Influx below kick margin, and successfully regained barrier with standard kill procedure without degrading well integrity.
	1	**2. Low risk shallow gas**	2. Shallow gas incident with dynamic kill operations. No gas handled on installation.
	1	**3. Low risk shallow water flow**	3. Shallow water flow incident with no risk for stability of installation.
Non Classified (NC)	NA	**1. Uncontrolled non-continuous gas/water migration in well - with all barriers in place**	1. Typical when releasing a barrier element with gas/water trapped below and adequate procedures not initiated

Pink = *Alert to PSA according to management regulation §29*
Blue = *Notification to PSA according to management regulation §29*

The matrix shows the categories of well control incidents that could lead to a blowout, the categories are further detailed in the guidelines with examples. The RNNP categories in the second column refer to the different probability for escalation into a blowout based on empirical data, e.g. a regular well control incident (category 1) has the probability of 0.002 to result in a blowout, while a serious shallow gas flow (category 5) has a probability of 0.5 to result in a blowout.



These figures show the distribution of well incidents, including shallow gas, for exploration and production drilling – normalized per 100 spudded wells the actual year.

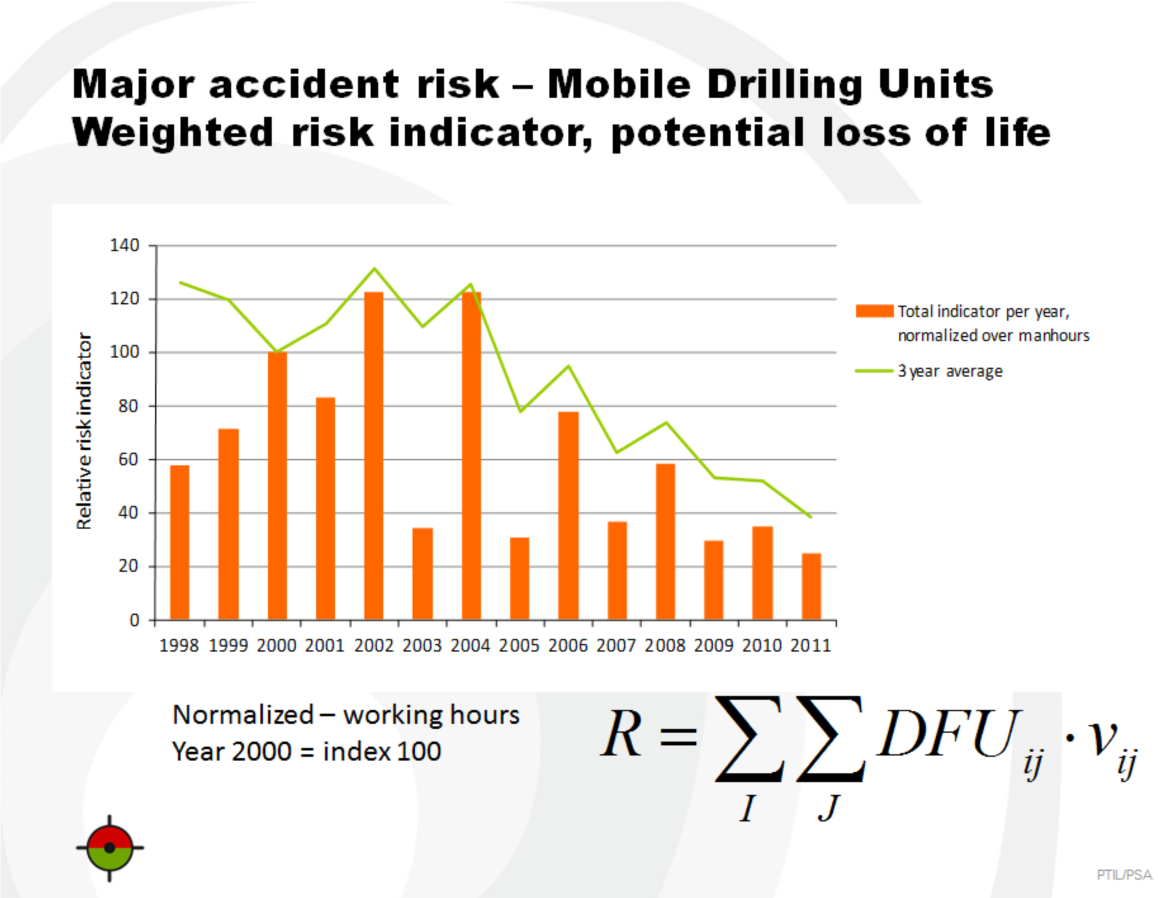
Since 1996 we have registered 298 well control incidents in total or approximately 18 per year which fulfill the criteria for counting in the RNNP database.

We observe that for exploration drilling the number of incidents per drilled well fluctuates. On average there seems to be around 15 incidents per year per 100 spudded wells. This rate was halved from 2006 to 2008, but in 2009 we found that the rate increased and even worsening in 2010 to 20 per 100 spudded wells. While in 2011 we saw a decrease down to 11 incidents per 100 spudded wells. This reduction however was not significant. The actual numbers of well control incidents within exploration drilling in 2011– not the normalized number - were 6 well control incidents. 3 was defined as regular well control incidents, which belongs to the lowest risk class with respect to develop to a blowout, while 3 was defined as shallow gas incidents, which belongs to the next highest risk class.

For production drilling we observe a positive trend from 2003 to 2008, but again with a slight increase in 2009 and further up to the highest level for the period in 2010. In 2011 the rate has decreased again to 6 well control incidents per 100 wells.

In actual numbers we had 7 well control incidents in relation to production wells in 2011. All was regular well control incidents.

Major accident risk



As mentioned earlier 10 of our indicators are related to major accident risk in relation to the potential for loss of life. This figure shows the major accident risk for mobile drilling units for the period from 1998 til 2011.

This major risk indicator was established on the basis of a standard risk equation; likelihood multiplied with consequence equal risk. In this case the frequencies from each of the 10 major accident precursors are multiplied with its respective weight factor in relation to the potential loss of life[7]. This is summed up for all precursors for all mobile drilling units in this figure, but it could have been done for single indicator categories or group of units as well.

A three year rolling average is used in order to clearer demonstrate the underlying trend. Year 2000 is set to index 100 and the risk level is normalized using work hours.

Since risk as a concept always deals with the future – this figure does not represent risk per se. It illustrates the combined effect of frequency and potential based on historical events. However, a

[7] R: Risk level; DFU_{ij} : Defined situation of hazard (DFU) number i for facility j.
v_{ij} : Weight of DFU nr i for facility j , $v_{ij} = EX_{ij}$: expected number of fatalities by DFU nr i for facility j

positive trend on this level indicates that the future risk based on history is decreasing, given the statistical uncertainty in the data and model.

For mobile drilling units, we see that in recent years the major accident risk indicator has established itself at a lower level than in the period before 2005. If we look at the underlying trends (represented by 3-year averaging) there is a clear positive trend in recent years.

The largest contribution to risk in 2011 at MODUs was:

59% Structural damage to platform: Stability / anchoring / position failure

37% Well incidents

OUTPUT

The output from RNNP is a general report and summary report on the industrial level[8]. The results are presented for Safety Forum (tripartite arena) where areas for improvements are identified. The "problem owners", i.e. industry actors are then being challenged to identify measures and implement improvements. Examples of former areas where the industry has been challenged are on: Anchoring failures, collisions, hydrocarbon leaks and well control incidents.

[8] http://www.ptil.no/news/trends-in-risk-level-2011-moving-in-the-right-direction-article8493-79.html

The RNNP yields data on company and facility level which is used in dialogue with the companies in order to point out areas for improvement, but no results on identifiable company are published. The results also help to prioritize the PSA's efforts both when it comes to strategic priorities and when planning for supervisory activities[9]. At the strategic level regarding major accident we have prioritized[10]:

> Management and major accident risk; Management at all levels of the industry must work to reduce major accident risk, and ensure that this work is pursued in an integrated manner.
>
> Barriers; Safety barriers must be maintained in an integrated and consistent manner in order to minimize the risk of a major accident.
>
> Natural environment; The industry must work purposefully to prevent accidents which can cause acute discharges.

Conclusion

To establish a broad range of leading and lagging key performance indicators in the area of major accident and to maintain these indicators are demanding work, BUT, for the Norwegian petroleum industry it is proven very useful in order to identify, monitor and improve safety. RNNP will continue also in future and indicators are continually improved – based on tripartite cooperation, industrial experience and international research expertise.

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[9] Data from RNNP are widely used in research and development both national and international and several articles are published during the years.

[10] http://www.ptil.no/priority-areas/category173.html?lang=en_US