Preventing pollution in sensitive areas

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1. Background

In Norway, we consider cooperation between companies, unions and authorities to be crucial for petroleum activity, in general and in safety matters. Towards the end of the 1990s, this cooperation suffered from disagreement among the parties and different perceptions of main safety challenges were a major concern. As a result, the Petroleum Safety Authority Norway (PSAN) initiated a project to gather and process information about safety performance on the Norwegian continental shelf (NCS).

Both the companies and unions trusted that the PASN had necessary independence and impartiality to own this initiative. Nevertheless, fundamental assurances were necessary to gain access to the different companies' information. The authorities guaranteed that performance monitoring would have a cross-company focus and that no company-specific performance data would be disclosed to the public.

In a task force led by the PASN, representatives from companies and unions cooperated with university experts to decide what data to collect and how to process them. Since 2000, we have published a report each April that presents accident and incident trends in Norwegian petroleum activity (RNNP). Every year a process of interaction between companies, unions and government agencies is spurred by the RNNP report. This process has contributed to restoring conditions for cooperation among the parties and to a shared understanding of safety performance. Therefore, the RNNP plays an important role in Norwegian petroleum activity.

Today, RNNP is a central management tool for all participants in the petroleum sector. It enables agreement about critical issues that need to be addressed and provides a basis for initiating common improvement projects, planning of supervision activities and developing regulations.

The RNNP has been under continuous improvement since its beginning. From a sole attention to safety performance in offshore activities, the process has developed and encompasses today also land-based plants, test data for different technical barriers, maintenance data, as well as questionnaire-based surveys of working environment. The initial focus was on incidents actually or potentially affecting the safety of personnel. Later on we have included data about incidents resulting in acute pollution at sea and near-miss events that could have led to acute pollution. Each fall since 2010, we have published a separate report about trends concerning acute pollution (RNNP-AU). This particular expansion of safety performance monitoring is the subject of this paper.

In this article, we will explain why a safety authority takes interest in incidents resulting in acute pollution. We also present results from our monitoring work and discuss the relevance of this information to major accident prevention in environmentally sensitive areas. We will not cover particulars of the methodology used to devise risk indicators from these data. These are classical statistical assessments that have been presented in numerous papers before. Neither are we concerned with questions about the environmental impact of pollution from petroleum activities. Our discussion is restricted to accident prevention.

The remainder of the paper is organised as follows: Section 2 discusses the concept of safety that applies in Norwegian petroleum activities, and the consequences of its particularities. In Section 3, we will present some of the trends concerning acute pollution on the NCS from 1999 to 2016. Section 4 contains discussions about the value and limitations of the information provided and highlight how it may be used by different parties, in general and in sensitive areas.

2. The concept of Safety

Safety is defined in the Petroleum Act (ref. 1), and it largely explains the authority delegated to the PASN. Safety as it applies in Norwegian petroleum activities, is different compared to definitions of safety used in other legislations. Our safety concept is described within a triple helix expressing fundamentals of accident prevention.

Firstly, safety includes "measures to prevent harm to personnel, environment and financial assets, including measures to maintain production and transport regularity (uptime)". Thus, safety concerns prevention of harm. This recognises that harm may result from normal activities, not only from non-conformities, errors, failures, incidents and accidents. It also signifies that measures shall be in place to prevent harm whenever deviations from normal activities occur.

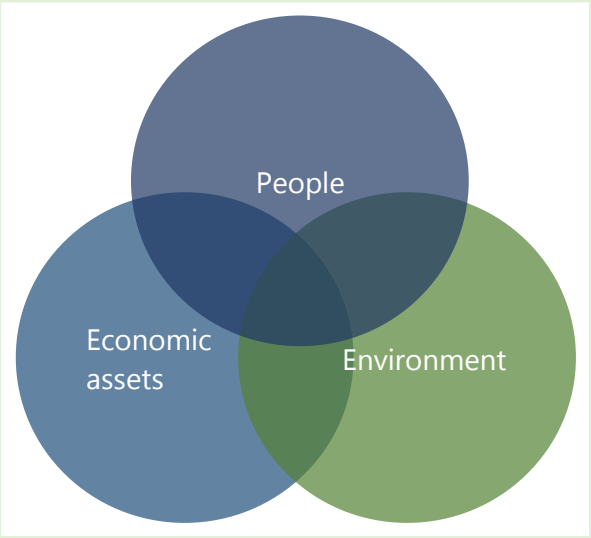

Figure 1 Safety

Another important aspect with this sentence, is that safety concerns prevention of any harm. It implies that accident prevention is required when personnel are not at risk such as on unmanned or subsea facilities. It also acknowledges the fact that the same operational conditions and the same barriers prevent a wide range of unwanted incidents with potential to harm different values. The same safety measures serve multiple purposes and their function may be of varying importance for different values. Justification for a preventive need may therefore be sought with regard to different values.

There is also need for a holistic approach and cross-value assessment to handle potential conflicting effects of safety measures. A particular chemical may be necessary to drill a well safely at the same time it may introduce a risk for instance for personnel in the mud room. Both well safety and personnel safety are required.

Secondly, safety measures "shall be implemented such that near-misses can be prevented, endured or averted." The sentence frames the ambitions conveyed by the notion of safety with respect to prevention. It communicates that prevention first and foremost, is expected to be inbuilt in design and operations, and that barriers are a secondary level of defence against deviations from a normal status.

Thirdly, it is specified that safety measures "shall prevent both minor harm, major accidents and disasters." This is an acknowledgement of the fact that petroleum industry is a high-risk industry, and that preventive measures cannot only be directed towards minor incidents. Measures to protect against low probability/high consequence accidents are also required. Behind our concept of safety

there is also a recognition of the fact that low statistical probability is not informative about risk in a particular operation, conducted by a particular company at a particular time.

This sentence also reflects that safety regulations exist to protect values beyond the interests of a particular company. All accidents shall be prevented because they may cause harm beyond a particular company, and even inflict upon society as a whole.

The concept of safety is fundamental both for the writing and the reading of our legislation. It frames all requirements about accident prevention for all companies involved in Norwegian petroleum activities, in all areas, also sensitive areas. It frames inter alia requirements concerning barriers to detect irregular situations, to avoid their development and to stop eventual accidents. The requirements apply whether activities are manned or unmanned, surface or subsea, linked to a gas or oil reservoir.

The definition of safety also conditions what is required when a near-miss event, incident or accident actually happens. Any event is regarded as symptomatic of a dysfunctional barrier, which in turn may be signalling something more serious. Companies shall therefore identify what needs attention and consider if the dysfunctions are symptoms of a larger problem. Most barriers protect against accidents of different severity and prevent harm both to personnel, environment and financial assets. It is therefore important to give attention to all sorts of unwanted events, because they give information about the same barriers.

3. RNNP-AU – results and identified trends

Norwegian HSE regulation requires that companies have a necessary overview and control of their activities. It includes monitoring and follow-up of unwanted incidents to continuously improve safety performance. A duty to report incidents to the authorities comes in addition with an aim to provide authorities with an understanding of the companies' overview and control. Regulatory requirements address amongst others registering, processing and use of data about unwanted incidents. These are data that support the companies' own processes aiming at overview to enable control and improvement. The RNNP makes use of the same data in pursuit of further improvement of accident prevention on the NCS.

Data collected in the companies cover a wide range of unwanted incidents including acute discharges to sea. Regulations require yearly reporting to a national database (EPIM Environmental Hub) about acute discharges of either oil, chemicals or refined oil products. The duty to report gives the authorities an overview of status and trends in pollution at sea resulting from Norwegian petroleum activities. The RNNP use these data to address performance of barriers supposed to prevent unwanted events, whatever consequence they may have.

Since 2000 and the beginning of the RNNP work, the PASN has built a database with company data about incidents actually or potentially affecting the safety of personnel. This database is also useful to extract information about incidents that could have resulted in acute discharges, had more barriers failed. Such incidents are regarded as near-miss events below.

In RNNP-AU, we use data about incidents with acute discharges and near-miss events. The data are used to monitor the effectiveness of barriers which function is to prevent a broad range of accidents and to minimize their severity. Thus, the RNNP-AU utilizes data that companies already report and does not add to the burden with new requirements. It is only a matter of getting more information from the same data.

We present examples of results and identified trends below in the period 2001-2016.

Acute discharges of oil

The concept of safety require that *any event* is regarded as symptomatic of a dysfunctional barrier, which in turn may be a signal of something more serious. In line with this, the indicators include incidents of acute pollution regardless of volume sizes and consequences for the environment. The incidents stem from petroleum activities on the NCS without regard to type of activity. It is regarded as irrelevant if they occurred during manned, unmanned, surface or subsea operations.

Acute discharges of oil may result from fault, hazard or accident situations related to for instance process systems, drilling activities, subsea production systems, pipelines, risers, and systems for oil offloading and storage. The number of *acute discharges of oil* is one of our indicators.

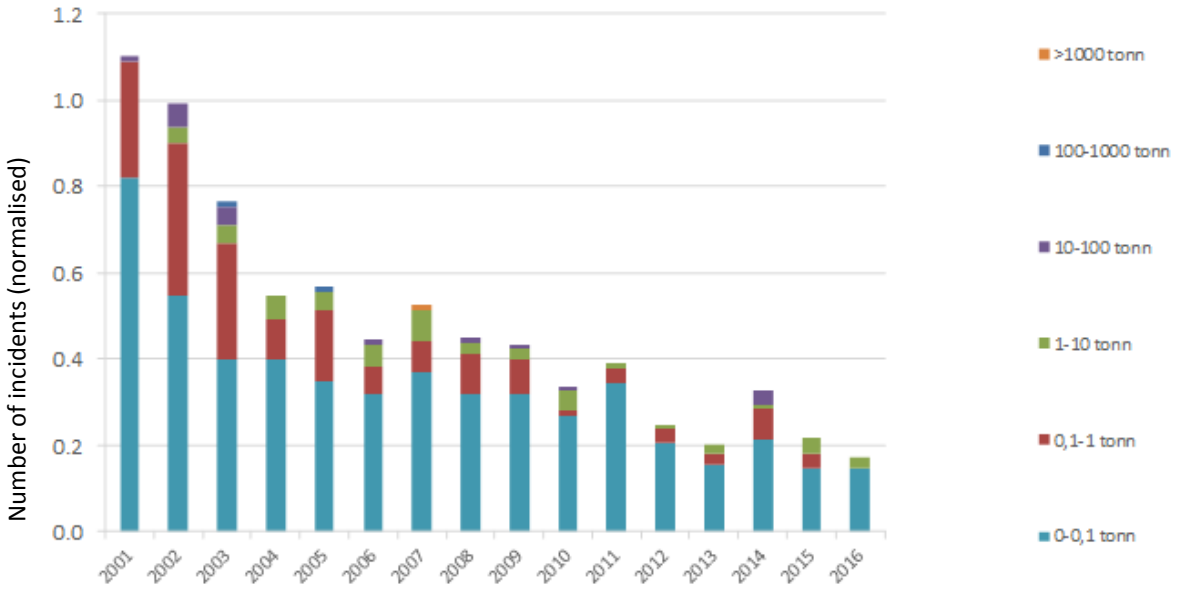

Figure 2 Number of acute discharges of oil, NCS

We see a decreasing trend in the number of incidents between 2001 and 2016. In other words, existing barriers seem to fail less frequently in 2016 compared to 2001. However, it is primarily the number of oil spills of less than 100 kilograms that have been reduced. Incidents with discharge amounts larger than 10 tons are few and the amount of data limited. These more severe incidents occur from time to time and there is no clear improvement.

We also monitor the *total amount of oil* to sea that results from incidents with acute discharges, as displayed in Figure 3 below. This indicator provides supplementary information to the above and indicates the overall severity.

The total yearly amount varies greatly throughout the period. There are signs of a positive development since 2011. With the exception of 2014, the total yearly amount has been below the average for the period as a whole. In 2014, however, three incidents with discharges between 30 and 50 tons occurred in the North Sea. This indicator is highly sensitive to more severe incidents and single incidents with larger oil spills are behind the peaking values of 2003, 2005 and 2007.

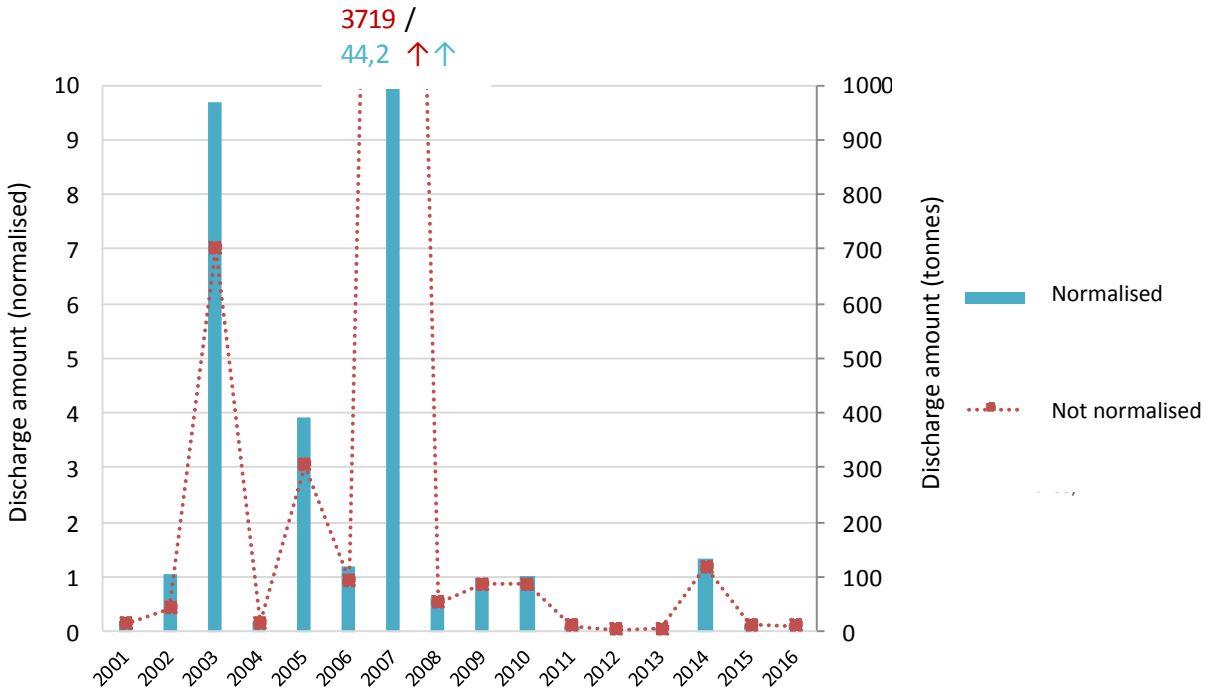

Figure 3 Total amount of oil to sea, NCS

Based on the above, there is need to consider the relevance and effectiveness of barriers when it comes to preventing more sever incidents. We also point out that when it comes to monitoring safety performance the number of incidents is an unreliable indicator for severity.

Near-miss events

The relevant near-miss events are those where barrier failure and escalation could lead to oil pollution. Hydrocarbon leaks from process systems, well control incidents, structural hazards as well as leaks from and damage to subsea process systems, risers and pipelines are relevant hazard and accident categories. We monitor developments and trends in the *number of near-miss events* in these categories.

The overall *number of near-miss events* show a positive trend (Figure 4). Yet, the trend seems halted or perhaps reversed the last few years.

We look at single hazard and accident categories (colour code) to get a more nuanced understanding. It is evident that vessels on collision course tend to occur more seldom the last few years compared to the first part of the period. The observation indicate the effectiveness of traffic control systems that monitor vessel movements near offshore facilities.

In addition, hydrocarbon leaks from process systems show a positive trend. However, if we look at the development for process leaks in the highest leak rate category (> 10 kg/s) there is no observable reduction in numbers. There are few incidents and their number vary throughout the period. We neither observe a clear improvement when it comes to well control incidents nor leaks from or damage to subsea facilities, risers and pipelines.

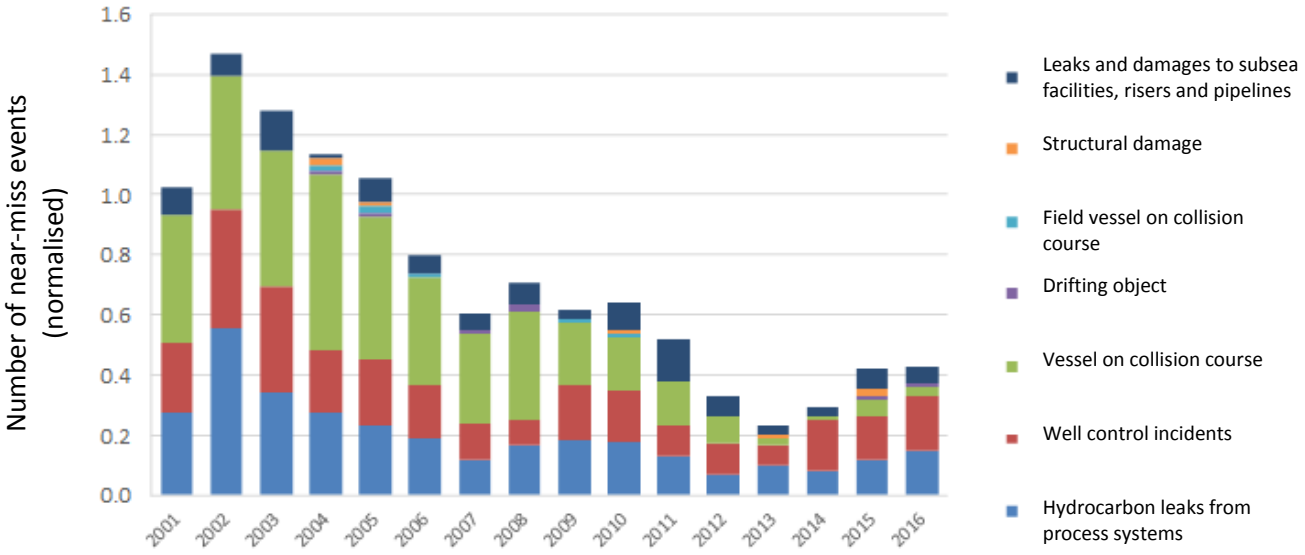

Figure 4 Number of near-miss events

We supplement information about the number of near-miss events by indicators of *severity* by use of risk analyses. The resulting picture depends on general assumptions and simplifications, and is only one of many possible. However, over time we get indications of how the severity of near-miss events with regard to acute pollution develops.

Given the actual near-miss events, we address severity through indicators of development potential. These express both *potential number* and *potential volume* (Figure 5) of acute oil discharges.

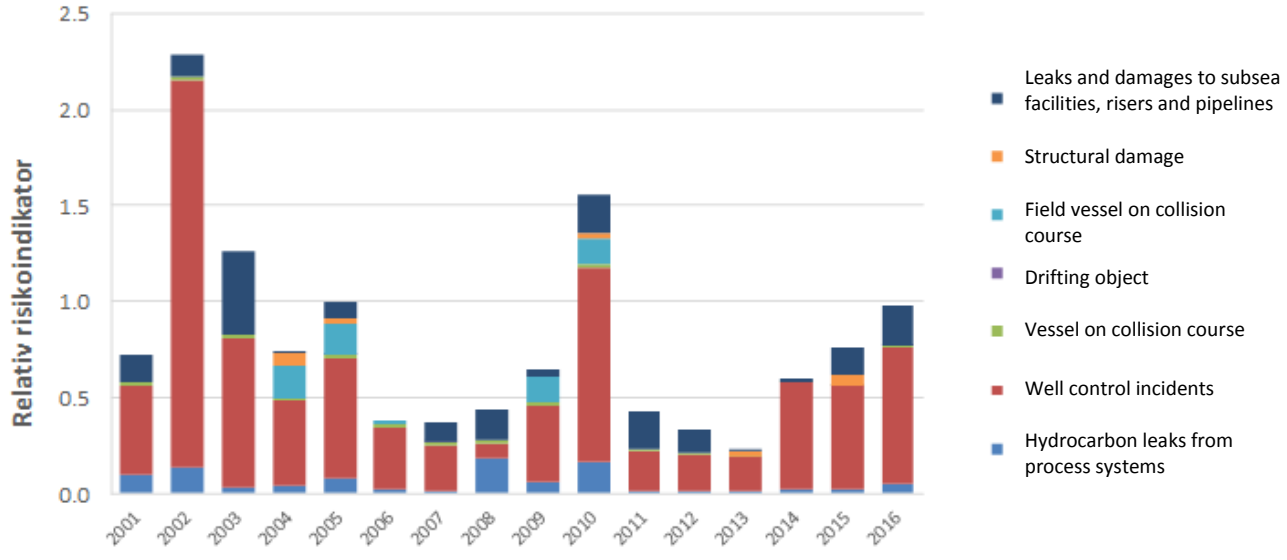

Figure 5 Development potential, discharge volume (oil)

The yearly results for both indicators vary throughout the period without a noticeable trend. A reduced number of near-miss events due to fewer vessels on collision course and fewer process leaks seems to be an insufficient indicator of severity with regard to acute pollution.

The relative contribution to severity of different categories of near-miss events points at an explanation. We observe that damages to or leaks from subsea process systems, risers and pipelines contribute the most to the potential number of acute oil discharges throughout the period. The potential volume of oil is greatly influenced by well control incidents.

We observe that although there is a reduction in the number of near-miss events between 2001 and 2016, the development is not equally positive for all categories of near-miss events. In later years, there has been a tendency towards decreasing numbers and well control incidents influence this result.

When we look at well control incidents in isolation, there is no clear improvement neither in number of incidents nor in development potential. We also observe that well control incidents stand out more in assessments of severeness with regard to acute pollution than in assessements made with regard to personnel harm.

Consequently, assessing the same incidents from different angles may provide earlier warnings about barrier issues. Barriers are in place to prevent a wide range of events. The events that actually occur are often events less varied and less serious than the events that established barriers are intended to sustain. This is the reason why we seek to draw the most out of available data about incidents and accidents by looking at them from different angles. A particular type of incident may have a higher potential to lead to acute pollution than to harm personnel and draw attention to the performance of a particular barrier, which may have important functions for the prevention of a wide range of events.

Other observations

Our monitoring work shows that *acute discharges of chemicals* are by far the most frequent on the NCS. About 80 percent of acute discharges larger than a cubic meter are chemical spills. The *number of acute discharges* of chemicals seem relatively stable on a high level in later years. There is no indication of improvement in effectiveness of existing barriers and in work to prevent acute chemical pollution. It is still uncertain if this signals something about the integrity of barriers.

The *yearly discharge volume* indicates how the severity of these unwanted incidents develop over time. There is no observable trend throughout the period between 2001 and 2016. The last few years indicate a development towards increasing severity. The three largest acute chemical discharges in the period occurred in 2014 and 2015. All occurred in relation to drilling activities and two of them do not signal high awareness about the risk of acute pollution. Based on the above, we assert that acute chemical discharges demand attention and so do the barriers meant to prevent them.

We also collect data about acute discharges and near-miss event in the Barents Sea. The amount of data is too small for statistical analysis and comparison. The activity level has been high the last few years and consist largely of exploration drilling. At the same time, we see a development towards more acute discharges and well control incidents in later years. The data give no reason to assume that safety performance in the Barents Sea differs from the industry's performance in other sea areas. We expect attention to barriers that shall prevent acute discharges in the Barents Sea. There is also need to clarify whether challenges are area specific or of a more general character.

Summing up

Accident prevention is about being proactive, and while it is important to learn from events that have actually resulted in damage, it is equally important to learn from events that did not result in tangible harm, but had the potential to do so.

Safety is about preparing to avoid *imagined* accidents and learning from *actual* unwanted incidents, in order to be better prepared to avoid what *may* happen. Incidents provides information about the performance of barriers *in practice*. This is valuable information because the same barriers are meant to prevent a broad spectre of incidents and accidents that may be more severe and affect both people, the environment and economic values.

Incidents that have threatened personnel without resulting in an acute discharge may provide information about barriers that are important for the prevention of a broad spectre of events. The important information behind an unwanted incident is what preventive measures did not function as intended, and where improvements are necessary. That explains why we have given attention to incidents that have resulted or could have resulted in acute pollution to sea. It also explains why this expansion of the RNNP has not required more data collection from the companies.

4. Values and limitations

RNNP gives no simple answers to questions about safety or risk on the NCS, mostly because safety and risk are not simple ideas that can be described and measured like weight and height. Risk is in the future. It is not a stable condition, but changes and evolves continuously influenced by multiple conditions, both singularly and collectively. Safety is therefore created and recreated continuously in every single activity. It depends on knowledge and understanding of the particular activity at hand in its relevant context. It also depends critically on understanding the extent and the limitations of what we know. Likewise, the value of the information provided by RNNP resides in understanding its limitations.

Limitations of the information provided

The first point to consider is the time aspect. Incidents and accidents are the outcome of past activities and provide information about historical performance. This is information that may point at necessary improvements. However, an accident that has occurred is not the same as accident risk. What has happened is not the same as what may happen in the future.

Major accidents such as Texas City refinery (2005) and Deepwater Horizon (2010) show that information provided by incidents and accidents can be misunderstood and give unjustified confidence in the effectiveness of existing safety practices. A comprehensive review of research conducted on safety indicators (ref. 4) confirms that overreliance on historical performance is a recurrent issue. It points at a number of common misunderstandings and conclusions that demonstrate how the past is not a reliable indication of what may happen forward in time. The study warns against believing that information about incidents is reliable information about risk. In addition, the research shows that positive trends cannot be translated as a reliable indication that risk management practices are effective and that improvements of current practices are unnecessary. It highlights the necessity of particular caution when it comes to drawing conclusions from historical trends in matters that concern low probability/high consequences events. Minor incidents cannot inform about major accident risk.

We also have recent experience of our own regarding the deceptive nature of past experience for predicting future safety performance and major accident risk. Our RNNP press conference in 2016 pointed at a decreasing trend in the number of incidents related to helicopter transport as the most

positive result. Already the day after, a major accident occurred when a helicopter crashed and thirteen persons lost their lives. It is important not to jump to conclusions about risk or safety based on pictures of historical performance.

The second point is to acknowledge that information is partial. Results from different indicators should be connected and assessed together with other available information. As discussed earlier, the RNNP demonstrate that the number of incidents is a poor indicator for the magnitude of consequences. The parts of RNNP that address personnel safety consider the effectiveness of barriers within the safety zone, while the parts of RNNP that address acute discharge inform also about barrier performance outside the safety zone, thereby addressing important safety issues for subsea installations. Results from RNNP may be complemented with information from regulatory supervision and investigation reports, thereby providing more precise and nuanced information.

The third point to consider is the context. In RNNP a 'continental shelf' perspective is adopted to assess safety performance. Relevant data are collected across companies, geographical areas, petroleum activities and development solutions. Assessments provide generic information that need to be interpreted with care. There are considerable differences between companies and offshore facilities, both when it comes to performance, challenges and needs. Generic results may mask single player performance and be insufficient for targeting necessary improvements. Therefore, the relevance of RNNP results should always be considered by industry players in their relevant contexts such as a specific company or offshore facility.

The fourth point is to recognise the dynamic nature of knowledge. Safety and accident prevention is conditioned by our ability to recognise risk in a dynamic environment, and therefore address uncertainty rather than seek certainty. RNNP provides information about a dynamic environment, not about stable achievements and sure projections. Oversimplifying the conclusions that can be drawn is risking complacency and inertia, thereby compromising the effectiveness of accident prevention.

Value of the information provided

The information provided by RNNP is valuable on many accounts.

The first advantage of RNNP is to secure regular and transparent information about safety performance in petroleum activities. The information provided is updated and qualified through processes involving the different parties. It is published in yearly reports and shared through various presentations to industry players, workers' organisations and the general public. The PASN is process owner, in order to retain the independence necessary to maintain trust in the information provided.

A second advantage is that it provides information about safety performance beyond what individual companies can generate. It caters for exposing issues that may concern all players on the NCS, players in a specific area, performers of a particular activity, or groups of players. It allows for comparison of safety performance in different geographical areas and makes it possible to distinguish between common and area-specific issues. This enables a more fine-tuned problem definition and more appropriate priorities. Identification of common issues enables cooperation among players and more efficient solutions. It facilitates the justification of initiatives from industry organisations, trade unions, authorities and tri-partite initiatives.

A third advantage is that it allows companies to benchmark their own performance and their own approach to performance monitoring. RNNP results are supplementary to the information generated by company-specific tools, models and processes. This may trigger scrutiny in new areas, review of safety monitoring procedures or reassessment of how incidents and accidents are followed up in

practice. It may contribute to a more holistic approach to information available within a company and a more active search for patterns across facilities, organisational units, locations or contracts. This may develop the companies' ability to clarify whether or not identified problems are symptoms of a greater and more systemic problem.

A fourth advantage is that it encourages multidisciplinary assessments. The RNNP covers safety performance in offshore activities and land-based plants, test data for different technical barriers, maintenance data and a wide range of aspects of working environment. It promotes the need to consider links between barrier performance and maintenance performance, and between working environment and safety performance. It supports assessment of barriers in different types of events and across different functions. It challenges traditional silos between safety and environmental matters and links resources that usually are concentrated on specific issues isolated from others.

A fifth advantage is that it brings the different parties together in common processes, both about RNNP and about the yearly results from RNNP. This contributes to a community of knowledge and learning about critical safety issues in the petroleum sector. It allows for mobilisation of resources with a wide range of competences and is able to cover a broad spectre of issues. It supports confrontation of different perspectives and different interests, and thereby secures quality in and continuous evolution of improvement processes. Furthermore, common discussions about transparent data, models and results are crucial for maintaining a level of commitment and trust necessary to effectively address safety issues.

A sixth advantage is that it allows the safety authorities to be more pertinent and proactive in their function. It complements the information that the authorities gather from supervisory activities, research or national and international cooperation. Information as good as it gets, is important to enable authorities to understand what is needed and decide upon relevant, adapted and timely interventions. It helps the authorities to direct their scarce resources wisely in supervisory activities and improve effectiveness of their controls. It is also helpful to target for instance systemic issues and critical players, more pertinently.

Thorough information also enables better regulations and improved risk assessments when companies get access to new areas and need to address unfamiliar risks. As highlighted by investigation reports after the blowout on the Deepwater Horizon (ref. 2 and 5), the prevention of major accidents does not only depend on what companies know and do, but also on how they are challenged by the authorities. For example, investigations emphasised how authorities addressed unfamiliar risks prior to opening deep water areas with challenging geology.

Prior to opening new areas to petroleum activities, the authorities assess if this may introduce new safety challenges, and whether it require particular initiatives on the authorities' part. Such risk assessments address risk in an area perspective and cover larger issues than assessments made with a company view. Authorities' risk assessments address more generic issues and issues that are relevant for all companies in an area, rather than well-specific issues at a particular location. They have to consider interests beyond those of a particular company and a lengthier period of time. Thus, the authorities' risk assessments are different from those performed by the companies, and they come in addition to assessments of risk made by companies with their more narrow perspectives. Authorities also lean on different kinds of risk reducing measures. While a company reduces risk with the help of barriers and other precautions, authorities reduce risk through their regulation, controls, interventions and initiatives to influence standardisation, cooperation or research.

The information provided in the RNNP support authorities' risk assessments, as it gives insight in safety performance across company boundaries and inform about the character of companies

moving into new areas. For example, there are too few data about incidents and accidents in the Barents Sea to allow for generic conclusions. However, the RNNP opens for relevant discussions about safety in the Barents Sea. The results that concern all areas on the NCS provide information about the performance of an industry and represent a valid reference for how this industry may perform in new areas. Some of the issues that RNNP actualise are not area-specific, but rather issues that concern all companies or particular groups of players that intend to be active in new areas. This is information that, together with other available information, enrich the risk assessments that the authorities perform.

5. Conclusion

A wide framing of safety and continuous improvement is fundamental to major accident prevention as advocated by Norwegian HSE regulation. The RNNP project is an important tool that supports our effort, as safety authority, to facilitate continuous improvement of accident prevention in our national petroleum industry.

The RNNP does not provide unambiguous answers about safety or risk, but rather evidence to support good questions about current practices. It covers accident prevention in general, including prevention of acute pollution. We believe that discourse about safety performance and resulting processes of follow-up both within and between authorities, companies and unions are relevant for preventing major accidents. This applies both in existing and new areas of petroleum activities.

The RNNP exposes information about the industry's safety performance to the wider public. It communicates that accident prevention is critical to avoid environmental harm. This is an important message in the aftermath of the Deepwater Horizon accident.

It is crucial to acknowledge the importance of society's perception of risk and its confidence in the industry's ability to prevent major accidents and acute pollution. This is increasingly important when the oil and gas industry's has ambitions to operate in sensitive areas. The need to demonstrate environmental stewardship becomes more pressing and preventing polluting accidents is an integral part of this. The RNNP provides relevant information in that regard.

It is not sufficient to refer to statistically low probabilities and assert that the industry has major accident risk under control. The industry needs to demonstrate that safety matters in practice. If the industry cannot prove its ability to prevent discharges of lesser volumes, it cannot expect to be rewarded with society's confidence that more severe accidents and significant pollution can be prevented.

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