Proceedings of the 35th European Safety and Reliability & the 33rd Society for Risk Analysis Europe Conference
Edited by Eirik Bjorheim Abrahamsen, Terje Aven, Frederic Bouder, Roger Flage, Marja Ylönen
 Published by Research Publishing, Singapore.
doi: 10.3850/978-981-94-3281-3_ESREL-SRA-E2025-P4763-cd

Risk Level project in Norwegian oil and gas – 25 years anniversary

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The Risk Level project (RNNP) was launched in 2000 and presented the first results in 2001, with annual reports since then. The reports cover all petroleum activities offshore and onshore Norway, based on voluntary and mandatory submission of data from oil companies and rig owners. The reporting covers personnel injuries, major accident precursors, environmental spills, well barriers, topside fire and explosion barriers, marine system barriers, maintenance, crane and lifting incidents and accidents, working environment, safety climate, risk perception and work-related illnesses. The broad reporting over such a long period is unique, and has had a very significant impact in Norway, for authorities, employees and employers. The results have shown significant improvements over the 25 years period, especially in the first half of the period. The RNNP has been important to achieve consensus between the different parties about levels and trends, as well as focus areas for improvement and motivation for risk reduction. The paper presents some of the main trends in the indicators for occupational accidents, major hazards precursors and barrier performance. After nearly 25 years of successful operation, it is timely to consider possibilities for revitalisation of RNNP, and several options are considered in the paper.

Keywords: Risk assessment, risk indicators, major hazard risk, national risk levels, offshore petroleum.

1. Introduction

Work on the development of RNNP (Risk Level Project) began in 1999, and the first report, the Pilot Project Report, was published in the spring of 2001, with data for the period 1996–2000. Annual reports have ever since been published each spring. From 2006, a separate report was published for onshore facilities, after the Norwegian Ocean Industry Authority (Havtil, previously Petroleum Safety authority) was given responsibility for onshore facilities in the petroleum industry from 1 January 2004. A separate report for acute releases has been published in the autumn since 2011.

RNNP has 25 years anniversary in 2025, and it is prudent to review the initiation and the development of the initiative during the first 25 years. It is rare that authorities present the same report(s) for such a long period of time. This indicates that the RNNP has been successful during these years, but it is worthwhile to consider this situation a bit more closely in the following sections. It has been inspiring to be associated with RNNP for so long, the first decade as a methodology developer and coordinator/editor, later as member of the scientific review group.

The Risk level project was unique at the time when the first report was published in the spring of 2001, and it is believed that RNNP still is unique worldwide, as a national report that presents annual data on virtually all aspects of working environment and safety for all operators of installations on the Norwegian Continental Shelf (NCS) as well as for onshore petroleum facilities in Norway.

The Main RNNP report is an annual 250+ pages report in Norwegian, focused on exposure data and HES (Health, Environment and Safety) accidents and incidents in the petroleum industry, with separate reports for offshore installations and onshore installations (Havtil, 2024a).

A brief summary report (40–50 pages, Havtil, 2024b) is also published annually, both in Norwegian and English, covering offshore installations. Half a year later follows the RNNP Acute spills report annual report, with statistics relating to marine spills, this report is only available in Norwegian.

Presentation of various aspects of RNNP are presented by Tharaldsen et al. (2008) for safety climate and risk perception, Vinnem et al. (2006) and Heide and Vinnem (2008), Vinnem (2010) for major hazard risk. Recently, further studies of safety climate have been presented by Mathisen and Tjora (2023), Mathisen et al (2023) and Mathisen, Tjora and Bergh (2022).

Centre for Chemical Process Safety has conducted work on process safety indicators in the wake of the Texas City disaster. From what is available in the public domain, it appears to be focused on incident indicators, see Sepada, (2006) and Hale (2009). A broad overview of indicators for offshore petroleum is presented by Tang, Dawald and Olugu (2018).

2. History of Risk Level Project

There was a dispute between the major stakeholders in the Norwegian petroleum sector in the years before the turn of the century. Union representatives and authorities were extremely concerned that the risk levels were increasing in offshore operations and claimed that safety was as bad as the 1970s. Company management were claiming that 'safety had never been better'. Mainly due to this dispute there was considerable mistrust between the parties and lack of constructive communication about sensitive issues.

There was a need to have unbiased and as far as possible, objective information about the actual conditions and developments. The authorities, the Norwegian Petroleum Directorate (NPD) at the time, later the Petroleum Safety Authority (PSA) and now the Norwegian Ocean Industry Authority (Havtil), defined a project ('the Risk Level Project') of extended indicators, in order to fulfil these needs.

The Safety Forum was established to try to foster better relations between the parties, involving representatives from the three parties, employee unions, employer associations and authorities.

The Risk Level project was initiated in 1999 as an initiative under the management of the Safety Forum, intended to provide an objective basis for experience data from the offshore petroleum operations. The project progressed throughout the year 2000, in order to develop the necessary methods. The first report was presented early in 2001, based on data for the period 1996–2000.

The Safety Forum is still the 'owner' of the RNNP reports, performing annual approval of new reports and approval of new developments of methodology and data basis.

There are some groups that have been formed in order to assist the Safety Forum in the management of the work (Havtil, 2024a):

- HES expert group, with membership from companies and academia to assist in the quality assurance efforts
- Advisory group with membership from the three parties (employees' unions, employers' associations, authorities) to assist in the choice of areas for further development of RNNP.

One of the new developments from the start of the RNNP was the approach chosen to illustrate quantitatively the risk level associated with major accidents. Norway had a series of severe major accidents during the first 15 years of offshore operations, including several accidents on installations as well as helicopter accidents. More than 170 fatalities had resulted from major accidents in the period 1970–1985, with the total fatalities of 123 persons in the Alexander Kielland accident in 1980 as the major contributor.

The approach to major hazard risk is based on 'pre-cursor' events, such as hydrocarbon leks/releases from topside equipment and subsea installations, well kicks, ships on collision course as well as structural and marine systems failures. Statistics on occurrences of pre-cursor events are collected annually. The quality control is a significant effort to ensure that the number of pre-cursor events is correct.

Each pre-cursor event is multiplied with a weight, which shall represent the expected number of fatalities given the initiating (pre-cursor) event. This expected number of fatalities is a function of the severity of the pre-cursor event as well as the type of offshore installation. When all the weighted number of pre-cursor events are summed up, this represents the expected number of fatalities given the pre-cursor events. Finally, this value is normalised by dividing by the number of manhours worked in the industry, giving the indicator the same dimension as the Fatal Accident Rate (FAR), number of fatalities per 10^8 manhours.

Another statistical source is the number of occupational injuries, where the main emphasis is placed on serious injuries to personnel. The

definition of serious injuries is defined the regulations and follows international agreements. Underreporting of the serious injuries is unlikely, due to the severity of the injuries. Serious injuries are typically head injury, amputation, poisoning, burn injury, hypothermia, internal injuries, eye, ear or skin injury and medical disability.

Another extensive effort performed in the RNNP is a questionnaire survey that is conducted every second year, the last survey is from 2023. An 8-page questionnaire is sent to every employee visiting an offshore installation during a six weeks period, and responses may be provided by filling out copies on paper or electronically. The main parts of the questionnaire are demographic data, HES climate on site, evaluation of perceived risk as well as working environment issues.

The survey distributed 28,225 paper copies of the questionnaire in 2023, and received 5,461 responses, of which 75% were electronically submitted. Even though this is a low percentage response (19.3%), the data set is still huge. The responses had significantly higher percentage response from the beginning in 2001 and has been gradually reduced. At the same time the length of the questionnaire has increased gradually, as the wish to include more issues has increased. There may be an opportunity to simplify the questionnaire form significantly in the future.

The distribution of responses is about 40/60 between operator and supplier employees, and about 30/70 between mobile installations versus permanent (production) installations. In all of the surveys 95–96% of respondents have been permanent employees, with 4–5% responses from temporary employees/contractors. These values are the responses, the total number of employees and contractors is not known, but the suspicion is that few of the contractors are responding or are given the opportunity to respond, although in principle all persons working offshore should have the opportunity to respond. A similar questionnaire survey is conducted for employees on onshore facilities.

3. Long Term Trends

RNNP gives a unique opportunity to see long-term trends, as the reporting has been virtually unchanged since the first report in 2001, thus is a 25-year perspective available. Figures 1, 2 and 3 present the development of precursor events, hydrocarbon leaks (part of the precursor events) as well as serious injuries to personnel in the period 2000–2023, based on RNNP reports published in 2024 (Havtil, 2024a).

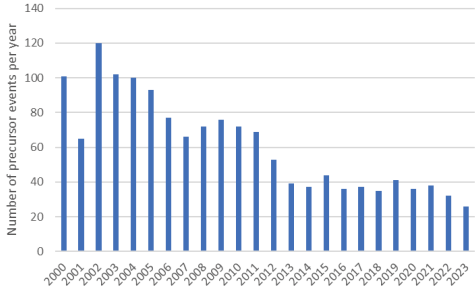

Fig. 1 Number of precursor events per year, NCS, 2000 – 2023 (based on Havtil, 2024a)

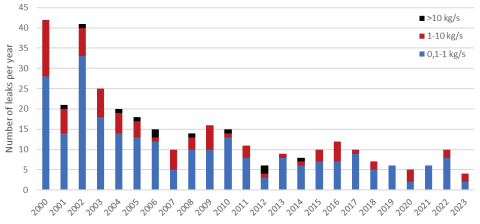

Fig. 2 Number of hydrocarbon leaks per year, NCS, 2000 – 2023 (based on Havtil, 2024a)

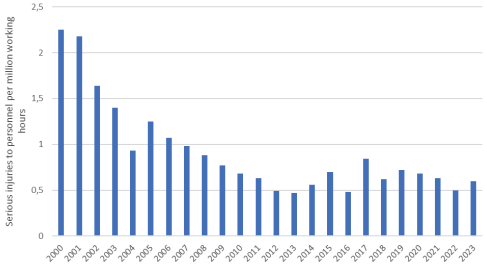

Fig. 3 Number of serious personnel injuries per 1 million manhours, NCS, 2000 – 2023 (based on Havtil, 2024a)

Figures 1, 2 and 3 all leave the same impression, a reduced trend in the first half of the period, followed by a constant level with minor variations.

The precursor events start with around 100 events per year in the first few years after 2000, and reached a low level in 2013, followed by a period of almost ten years with values just below

40 precursor events per year. The number of precursors dropped significantly in 2023 to 26 events per year, but it remains to be seen whether this is a permanent reduction or a temporary variation.

The number of hydrocarbon (HC) leaks (or releases) is included in the precursor events, but is often presented separately, as this category is the most significant contribution to precursor events. Only those leaks exceeding 0.1 kg/sec initial leak rate are included, smaller leak rates were not considered to have the potential to cause a major accident. This assumption may need to be slightly reconsidered. The total number of HC leaks (> 0.1 kg/sec) was around 40 per year just after 2000, and dropped to only six leaks in 2012, followed by a period with a constant level between 5 and 10 per year, until it dropped to 4 leaks in 2023. Also, for leaks it remains to be seen whether this reduction is permanent or a temporary variation.

The number of serious injuries to personnel (see categories above) on NCS was around 50 per year just after 2000 and has declined to 23 serious injuries in 2012 (24 in 2013, but with a lower frequency per manhour), corresponding to a frequency of around 0.5 injuries per million manhours with some variations, in the period after 2012.

Other indicators in RNNP also show the same pattern, lowest levels around 2013, with rising or stable levels in the ten-year period after 2013. This applies in particular to barrier element reliability testing as well as the biannual questionnaire survey conducted in RNNP.

Figure 4 shows a condensed summary of all topside barrier reliability during testing. Industry norms have been defined for each barrier element separately, typically in the order of 1–2% failure frequency.

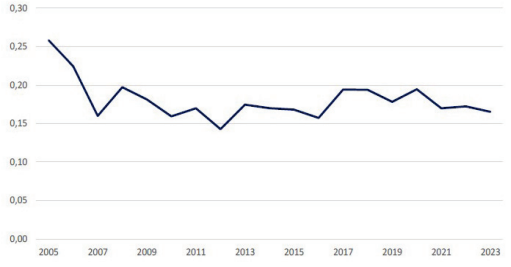

Fig. 4 Relative fraction of barrier elements with failure frequency above industry norm for all barriers, NCS, 2005 – 2023 (source: Havtil, 2024a)

Figure 4 summarizes the results for all installations and all barrier elements, where the failure frequency exceeds the relevant industry norms. The level has been constant the last ten years also in this case.

The questionnaire survey has many questions relating to working environment, physical as well as phycological as well as health, environment and safety climate. These indicators have shown a significant reduction in the responses towards worse conditions in the years following 2013. The results of the questionnaire survey are presented through a high number of diagrams and tables, often summarized through a significant textual section. It may thus be argued that the overall results from the survey are not easily observable.

It is noteworthy that 2013 is the year when the oil and gas prices dropped significantly worldwide, from over 100 USD per barrel to around 20 USD per barrel during a short period. A causal relationship between these indicators and the price of oil and gas has not been established, but one is inclined to assume that such a relationship is quite likely.

The last diagram is perhaps the most well known RNNP indicator as presented in Figure 5. The relative major hazard risk indicator is based on the major accident precursor events, each occurrence is multiplied by a weight, then the weighted events are summed up and normalized according to the total number of manhours on all NCS installations, both permanent and mobile installations. The weights express the expected number of fatalities per precursor event, according to the type and severity of each occurrence and the type of installation where it occurred.

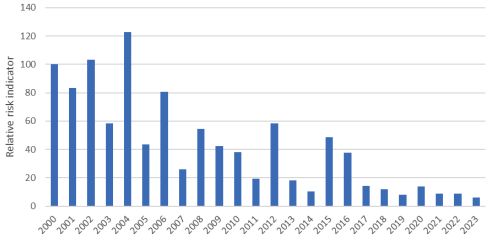

Fig. 5 Relative risk indicator for major accident risk, NCS, 2000 – 2023 (based on Havtil, 2024a)

The pattern of the diagram is similar to the preceding diagrams, in the sense that a signifi-

cant reduction occurred until 2013–2014, after which the level has been reasonably stable. The reduction from the level around 2000 is more extensive in Figure 5, compared to Figures 1, 2 and 3.

There are at the same time more significant variations in Figure 5, as the curve is strongly influenced by certain severe events with a high major accident potential and thus high weight. The RNNP report has included a rolling 3 year average in order to reduce the extensive variations.

4. Social Impact

The dispute between the major stakeholders in the Norwegian petroleum sector in the years before the turn of the century has been described above, together with the need to have unbiased and as far as possible, objective information about the actual conditions and developments.

The presentation of the pilot project report solved the dispute between the parties, the parties quickly accepted that the values presented by RNNP were the objective facts. Figures 1–5 in the previous section have demonstrated that the risk levels were not low at all, but the report initiated a process which after about ten years resulted in significantly lower accident frequencies.

The Norwegian government presented a White paper about health, environment and safety in the petroleum sector in 2001, and for the first time formulated the ambition that Norway should aim to be world leading in HES in the petroleum sector. This has since then been adopted by all new governments, employers' association as well as the relevant trade unions. A similar ambition has also been adopted by the parties in the UK.

An extensive study performed by Safetec (Safetec, 2023) demonstrated that the framework conditions for suppliers to the offshore petroleum operations as well as drilling had been severely deteriorated when all suppliers had to renegotiate contracts after the dramatic fall of the oil and gas prices in 2013/2014. The report concluded that risk to personnel associated with working environment as well as major hazards would be increasing as a result of these deteriorated contract conditions. These deteriorations may also be related to the lack of improvement in offshore HES in the last ten years, as documented in the previous section of the paper.

The political framework conditions have at the same time also changes significantly during the last ten years. Climate issues relating to the use of hydrocarbons for energy production has become a major issue for all parties. Some will feel that climate issues have taken over the role as the primary objective, a role which HES used to have in the past.

One follow-on issue resulting from this focus is the need to replace the hydrocarbon-based energy production for internal consumers on offshore installations with electricity supply from the shore, this is in Norway only hydropower and as such a sustainable power production.

Another political issue the last three years is the need to ensure a stable supply to Europe of Norwegian gas for European energy production, following the Russian attack on Ukraine.

Dr. Rolf Bye (in Vinnem, 2024) has formulated some interesting hypotheses about the reasons for the fundamental changes of framework conditions with the negative impact on working environment and safety:

1. Equinor's development towards monopoly contributes to the dominant player not considering the negative consequences of not "prioritizing safety work and employee involvement" (for example, loss of reputation, reduced access to licenses, enforcement fines, violation fees, etc.) as so serious, compared to the assumed gains of choosing a different strategy to HES. For the other companies, choosing a similar strategy will have a significantly greater downside risk.

2. The expected winding down of the petroleum activities (and limited potential for major discoveries) contributes to the potential downside consequences of not "prioritizing safety work and employee involvement" being assessed as smaller than previously.

3. Development towards purchasing monopoly contributes to the dominant player (buyer) having greater negotiating power over suppliers when entering into agreements. Equinor has made greater use of this power in recent years. The suppliers' adaptations (including changes in maintenance, competence and staffing management) have collectively contributed to a reduced ability to avoid and handle unwanted incidents.

5. Current Challenges

The Norwegian regulations are kind of unique in the sense that the operating companies in the

Norwegian sector are required to improve continuously their management of all aspects of HES. This requirement has been applicable for nearly 25 years.

There has been a tendency in the last few years that the operators are focusing more on 'good enough is good enough', and less on continuous improvement. This appears to be reflected also in the statistics, see Figures 1–3, which display significant improvement from year 2000 until around 2013/2014, and more or less stable levels in the ten years following the dramatic drop in oil prices.

This is most explicitly reflected in the new approach to risk assessment of new installations, where reuse of risk assessment for previously accepted installations plays a significant role. This is actually in line with the approach adopted in the international standard ISO17776 (ISO, 2016), but it is nevertheless not in accordance with the special Norwegian requirement for continuous improvement.

The changes that have been implemented during the last few years are believed to reflect some of the changes in market and future downsizing of the industry as discussed in the previous section. The resulting policy change appears to increase the focus on cost-cutting and profit maximation, with decreased focus on health, environment and safety.

At the same time it appears that also authorities are refocusing their interests. Authorities with previous HES responsibility for offshore petroleum operations have both in UK and Norway had their responsibility increased to also include offshore wind turbine power generation as well as CO_2 injection into subsea reservoirs. It is thus becoming more challenging to maintain the high focus on petroleum HES. In Norway the authorities have also got the responsibility for future subsea mining of minerals.

One special effect of this change in focus is also seen in the academic world. Norway has had an extensive R&D portfolio relating to HES improvement in the petroleum sector for several decades, starting in the late 1970s when the industry was novel and the number of major accidents and occupational accidents were at much higher levels.

But the last 10–15 years, the R&D efforts in the HES field has been significantly reduced and is currently at a level which is just a small fraction of previous levels. The Norwegian research council has been complaining about the lack of good proposals from industry as well as the academic world.

6. Further Development

The Risk Level project, RNNP, has been described as highly successful in the first two decades of operation. Some experts will argue that the success rate has dropped the last years, consistent with the drop in focus from the industry as described above.

It is thus relevant to consider how RNNP could be refocused in order to stimulate the industry to increased focus on improvements. The long life of the RNNP with essentially the same approach makes this natural to consider.

One approach to further development of RNNP could include making results more transparent, or more easily accessible for decision-makers. As already mentioned, the overall indicator for major hazards is probably the diagram that is most often referred to, see Figure 5. But this is overall indicator only for major hazards, based on occurrences of precursor events which may result in major accidents, if all barriers fail.

An alternative would be to develop an overall indicator for all aspects of major as well as occupational accidents, barriers, working environment as well as safety climate (or culture). This would facilitate more transparency in the communication of all the results in RNNP, not only major hazards.

The current overall indicator in RNNP is quite specific in its interpretation, it is the occurrence of pre-cursor events and their potential consequences. It is relatively easy to explain intuitively to employees and all other concerned personnel.

An overall indicator for safety and working environment would be less intuitive and be more challenging to explain. It will also be dependent on the weights that each component is associated with.

Communication would probably also be more challenging. The overall effect would be transparent, but in order to explain how the results are obtained, it will in most circumstances be required to present the different components that contribute to the overall indicator, in order to illustrate how the different trends are influenced by the individual components.

Also another form of transparency may be useful. The current overall indicator is presented on a national level as well as separately for production installations and mobile installations. There are too few pre-cursor events to allow a presentation for each operating company. The only aspect where anonymous company data have been presented in the past, is for the frequency of unignited hydrocarbon leaks.

With a new overall indicator for safety and working environment, the data basis is significantly increased, and it would be justifiable to present company specific values at least for the large and medium-sized operators. Especially barrier data for production installations has significant volume of data. Also the volume of responses in the questionnaire survey is extensive.

When company specific values are presented separately, it will be more transparent which companies that need to improve their performance. It is thereby possible for the authorities to give more direct input to the needs for improvement.

It has been a tradition in RNNP to present results for anonymous companies, so the public is not given the information about which companies that need to improve their performance. At the same time, the companies themselves are given information about which anonymous code that they have, such that they can see their performance in relation to other companies.

A third extension of RNNP is to include other activities. When Havtil's responsibility has been increased to include offshore wind energy, offshore CO_2-injection and offshore mining, it would be natural to perform similar exercises also for these areas when operations are commenced.

A special case is the increased use of service operating vessels (SOV), which to some extent takes over offshore operations that normally have been conducted by offshore personnel on permanently manned installations. This may be replaced by temporary manning conducted by personnel who live on Walk-to-Work (W2W) vessels, passing over a telescopic bridge between the vessel and the installation in order to perform work on the installation. A similar concept is also used for maintenance of offshore wind energy installations.

It would be useful if the volume of such activities would be mapped out, together with incidents and accidents in this particular operation. There would also be a cross-industry learning potential, as the SOV concept is also used in offshore wind energy.

It has been suggested in the past that cyber and security risks should be included in RNNP, these have become much more prominent in the last few years. But cyber and security risks are different from risk to personnel, environment and installations. Threats and preventive measures can not be discussed openly in the public domain as in the case of threats to personnel, environment and assets. Inclusion of cyber and security risks would therefore have to be different in RNNP and should therefore not be included as part of RNNP.

7. Conclusions

The Norwegian Risk Level project for the petroleum sector has been successful for almost 25 years. RNNP covers occupational accidents, major accidents, barrier performance, maintenance efforts as well as working environment and safety climate.

The project was most successful in the first 15 years, where most of the indicators showed significant improvements, in many cases reduced frequencies by 50% or more. There was also trust between the parties and agreement about the challenges for safety and working environment.

There has been little or no improvement at all during the last ten years, and the trust between the parties has been gradually deteriorated.

At the 25 years anniversary of RNNP there is a need for revitalisation of the approach which was successful at the start of the project.

It will be important to maintain the extensive data collection in RNNP without reducing the scope or extent of this part of RNNP. The data collection has been proven to be very beneficial for the industry as a whole and should be continued.

This paper has proposed that the scope and extent of the overall indicator is increased in RNNP from a major hazard risk indicator to an overall indicator for safety and working environment, including major hazards as well as occupational accidents, barrier performance, working environment as well as safety climate.

Such an indicator would be less intuitive and more complex to describe and interpret, but it would provide a far better appraisal of the trends in safety and working environment.

Another proposal for RNNP is to present the overall indicator for safety and working environment in a way that allows benchmarking between

the companies. This would give a better understanding of how improvements may be achieved.

It has also been suggested that new activities within the responsibility of the authorities should have their own Risk Level documents, when these commenced.

Som have suggested that cyber and security risks should be included in RNNP. The paper does not recommend this inclusion. Cyber and security risks are different, and threats and preventions can not in the same manner be discussed openly in the public domain. Inclusion of cyber and security risks would therefore have to be different and should therefore be addressed in dedicated manners.

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