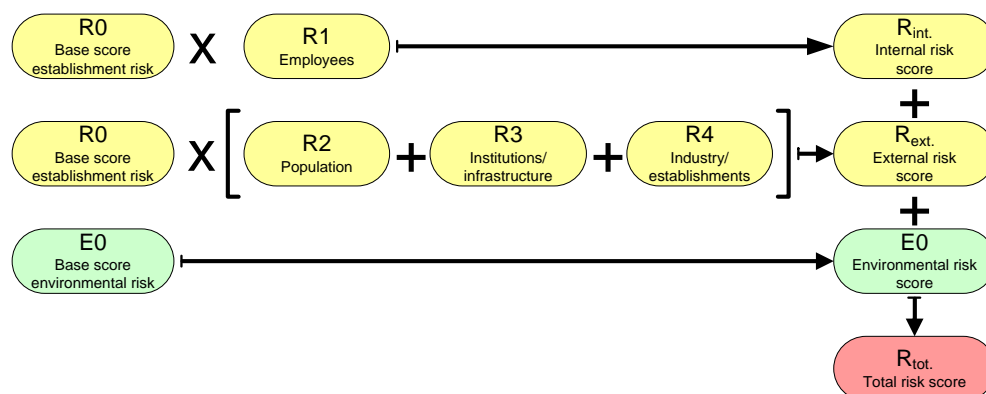


Report

Methodology for monitoring safety level development in and around Seveso establishments

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Methodology for monitoring safety level development in and around Seveso establishments

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ABSTRACT

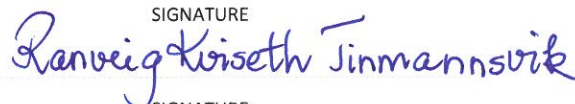
The report is written on behalf of the Directorate for Civil Protection (DSB) as a contribution to their work as a coordinating authority for the Seveso Regulation in Norway. The purpose of the work has been to identify information that can be used for periodic monitoring and evaluation of safety development in and around establishments that handle large amounts of hazardous chemicals.

Based on a literature review of similar work in other countries and a workshop with international participation SINTEF recommends a three part methodology for monitoring safety trends in and around Seveso establishments:

1. Method for risk classification of establishments
2. Method for developing safety indicators based on the regulators' inspection results
3. Method for developing safety indicators based on data submitted by the establishments

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Preface

This report represents the first phase in developing a methodology for risk classification and indicators to monitor safety trends in and around Seveso establishments. The work has been done in a close dialogue with our contact persons in the Directorate for Civil Protection (DSB), Ragnhild Gjøstein Larsen and Vibeke Henden Nilssen. Furthermore, there has been useful input from national and international authorities and from establishments that are subject to the National Seveso Regulation, especially from those who attended the workshop in Tønsberg, Norway 30 January 2013.

We would also like to thank the companies who have provided written response to questions about their practices and experiences related to the use of indicators to monitor risk/safety trends.

The work has been carried out in the period December 2012 - April 2013.

Trondheim, 22 May 2013



Ranveig Kviseth Tinmannsvik
Project manager

Summary

This report is considered as a first step in an effort to develop and implement a methodology for periodic monitoring and evaluation of the safety development in and around establishments that handle large amounts of hazardous chemicals. During the project it became clear that in order to establish such a methodology, there is a need for risk classification of establishments, i.e. give a method for establishing a list of the "built-in hazards/risks", with regard to both the employees and the surroundings/3rd party.

Establishments that are subject to the National Seveso Regulation ("Seveso establishments") include many different types of companies, from simple explosive storage facilities, fuel and gas depots to complex process industry. The companies therefore have very different risk potential and varying level of expertise and resources. Thus, it is important that the methodology is applicable for a wide range of establishments.

It is of great importance that the future methodology is understood and accepted by the industry. Therefore, it is important to use registrations already available in the industry, to avoid burdening the establishments with unnecessary registrations. A total of 13 companies (chemical processing industry) gave feedback regarding their use of indicators for measuring risk/safety trends, and also gave examples of such indicators.

Moreover, it was conducted a review and summary of similar ongoing work on indicators, based on a literature study and a workshop with international participation in Tønsberg, Norway 30 January 2013. A review of existing information available from the Directorate for Civil Protection (DSB) was carried out. This information is assessed with respect to its relevance for measuring the safety level development in and around Seveso establishments. The effort to develop a measurement tool for DSB is mainly based on experiences from Great Britain, Finland and the Petroleum Safety Authority Norway (PSA).

In total, it is suggested to develop a methodology in three parts, involving both risk classification and use of indicators for periodic monitoring of safety trends in and around Seveso establishments. When finalised, the approach will consist of the following three elements:

1. Risk classification of the establishments
2. Safety indicators based on the regulators' inspection results
3. Safety indicators based on data submitted by the establishments

The proposed safety indicators in Part 2 and Part 3 of the approach will not be based on a risk model; i.e. the indicators are not risk based. Thus, the observed values of safety indicators will not provide a basis for estimating the level of risk for the establishments. But from general knowledge about factors which affect operational safety it is assumed that changes in the value of safety indicators will demonstrate changes in the risk/safety level. This type of indicators is referred to as *safety performance based*.

The three elements of the approach can be used either in combination or independent of each other. Part 1 provides a risk classification that includes both internal and external risks to people and assets, as well as environmental risks. A score is calculated for each of these aspects of risk, and these scores will then be summarized to give a total score. This provides a relatively stable classification of the establishments, which has to be reviewed only if there are changes in the conditions at, or around the establishment.

Parts 2 and 3 represent the traditional safety indicators, which are monitored/ updated e.g. on an annual basis. When it comes to safety indicators based on results from inspections, a total of nine indicators are proposed. They relate to factors such as *compliance with regulatory requirements*, *management commitment* and *competence and training*. These indicators can be used either separately or also combined (taking an average) to give an overall rating. The proposed safety indicators, based on data submitted by companies, are

formulated as frequency of various events, test results, maintenance backlog and extent of closed measures. Our intention has been to cover all three categories of indicators:

- a) Outcome/ event based ("lagging")
- b) Technical/ operational, including the status of barriers ("leading")
- c) Organisational/ SMS - Safety Management System ("leading")

Considerable work remains to develop the methodology further, first to implement a set of indicators, and later to adjust the methodology and the number of indicators as experience is gathered. There is a need for a multidisciplinary approach and a coordinated work between regulatory authorities and establishments.

When it comes to risk classification (Part 1), the model for the calculation of risk scores seems to be the main challenge. It will require a significant effort to be confident that these balance the resulting risk score in a good way. The methodology also requires a definition and classification of establishment types.

As for Part 2, indicators based on inspection results, the suggested system for quantification is much simpler, and the authorities will presumably be able to establish such a methodology without too much effort.

However, Part 3, indicators based on data submitted by the establishments, will require a close collaboration with the industry, and a process leading to a gradual introduction (and subsequent increase in the number) of such indicators should be planned.

1 Background

The Directorate for Civil Protection (DSB) is the coordinating authority for the "Regulations for measures to prevent and limit the consequences of major accidents in establishments involving hazardous chemicals" (National Seveso Regulation), and cooperates with the authorities involved through a Coordinating Committee for the Seveso Regulation. DSB's main task is to ensure that land-based industries that handle hazardous chemicals are followed-up and treated in a uniform manner and that international obligations under the Seveso II Directive¹ is followed. DSB is the national contact point with the EC in relation to the implementation of the directive. DSB has a technical secretariat responsible for the practical implementation of the coordinating responsibility.

As part of the work as the coordinating authority for the National Seveso Regulation, DSB has decided to make an effort to identify possible measurement points or indicators for the assessment of safety development in and around Seveso establishments.

Companies that are subject to the National Seveso Regulation include many different types of establishments, from simple explosive storage facilities and fuel and gas depots to complex process industry. Establishments therefore have very different risk potential and varying levels of expertise and resources.

2 Objective

The purpose of this work has been to identify the type of information that can be used for periodic monitoring and evaluation of safety development in and around establishments that handle large amounts of hazardous chemicals.

The work should result in a system for systematic measurements relative to established indicators and measurement points. Beyond being able to say something about the development of risk level in and around Seveso establishments, the results will also be used in future prioritisations for authorities. DSB asks for measuring points/ indicators that reveal changes in the performance of the establishment's safety work in general, and changes in the risk level for the surroundings close to such establishments.

3 Choice of approach

There exist a number of different approaches and methods for the development of safety indicators. The indicators may for example be *risk based*, *event based*, *safety performance based*, *resilience based*, or simply based on a selection of indicators from what is already recorded, but without being rooted in any particular approach (Øien, 2010). It can also be a combination of these approaches. Within the individual approaches there are also specific methods, e.g. ORIM, HSE "dual assurance", REWI, etc. (Øien et al., 2011; Øien, 2001; HSE and CIA, 2006).

The various approaches are briefly described in Appendix B (see SINTEF's presentation). Risk based indicators are linked to a risk model. Using this model, we can estimate how a change in the indicator will affect risk. The other approaches will not provide such a relation; safety performance based indicators are based on the *assumption* that they are important for safety. Such an assumption can be based on sound arguments and relatively clear causal relationships, but is not based on a risk model, which makes it possible to quantify an assumed effect on the level of risk.

¹ 26th June 2012 European Council adopted a Seveso III Directive which will replace the current Seveso II Directive. Seveso III Directive will enter into force in the EU/ EEA countries by 1 June 2015.

The choice of approach depends on several conditions, including how the indicators should be used (for whom they should be a tool), available data to rely on, and the resources available for the development of the indicators:

- How the indicators shall be used is related to the level, i.e. whether they should be used for an entire industry, a group of enterprises, individual establishments or systems/ parts of an establishment.
- The basis for developing indicators can for example be risk analyses, selected incidents/ accidents, a framework of key factors (e.g. resilience factors/ success factors) or regression/ correlation analyses.
- Available resources (time, budget, assistance, etc.) are of course also very important for the choice of approach, because some approaches are more resource intensive than others. The document *Process Safety Performance Indicators* (HSE et al., undated) suggests, for example, a stepwise development and implementation of indicators of between 1½ and 2½ years.

In light of this, SINTEF suggests that DSB's tool for periodic monitoring and evaluation of safety development in and around Seveso establishments is based on the following principles:

1. Develop indicators in dialogue with affected establishments
2. Start with a small number of agreed indicators
3. Test out and implement a first set of indicators
4. Gradually develop the set of indicators

The work documented in this report forms the basis for the first two points.

A *safety performance based approach* is chosen, i.e. the selection of indicators is not based on a risk model. To some extent the approach is based on the 7-step process for the establishment of indicators proposed by the OECD (2008). This is because it is specifically targeted at chemical processing industry and because it is flexible and can be adapted to individual needs. The OECD has in its update of the 2003 version largely incorporated the methodology developed by Health and Safety Executive (HSE) and the Chemical Industries Association (CIA) (HSE and CIA, 2006). The Baker report after the Texas City disaster in 2005 when 15 people were killed in an explosion and fire refers to, and recommends this methodology (Baker et al., 2007; CSB, 2007). The OECD method is briefly described in Appendix E.

The work has been performed as a dialogue based process, because it is important that both the people involved from the DSB, and the industry itself has confidence in the indicators. The indicators are also evaluated based on more objective criteria. Examples of criteria are shown in Figure 1.

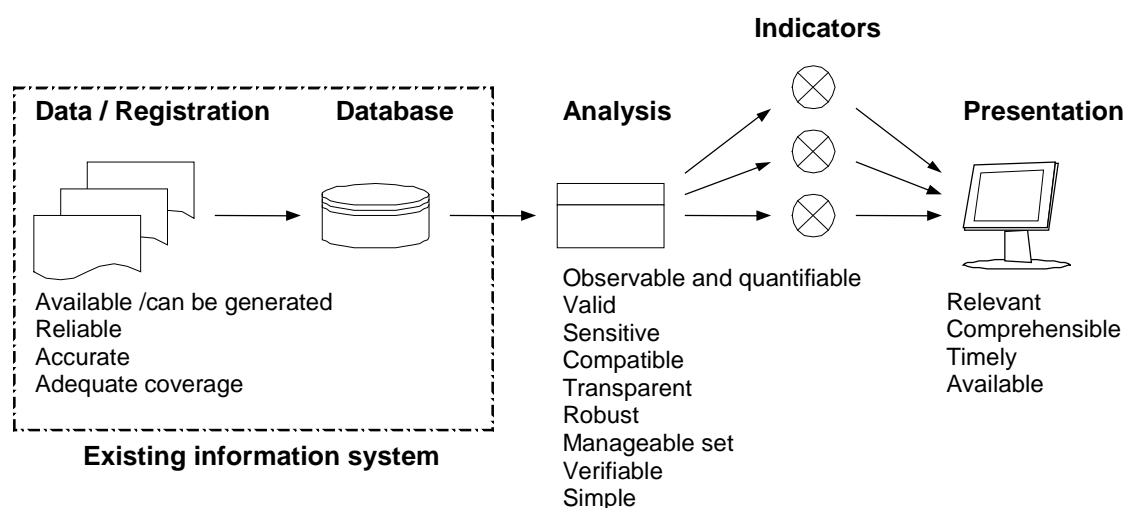


Figure 1. Criteria for evaluation of indicators (Samdal et al., 2004).

During the project it became clear that in order to assess the level of risk in and around Seveso establishments, DSB also needs a method for risk classification of these establishments, i.e. a method to give an overview of their "built-in hazards/ risks" with respect to employees and surroundings/3rd party. Therefore SINTEF recommends a three part methodology for periodic monitoring and evaluation of safety development in and around Seveso establishments:

- 1) Method for risk classification of establishments
- 2) Method for developing safety indicators based on the regulators' inspection results
- 3) Method for developing safety indicators based on data submitted by the establishments

The methodology is further described in Chapters 5, 6, 7 and 8. However, data collection is first discussed; i.e. reviewing the literature and information sources, which are the basis for risk classification and development of indicators.

4 Data collection

4.1 Different data sources

A variety of data sources are used. A review and a summary of similar work internationally have been made. This is based on a literature study and a workshop with international participation. Information from DSB and from Norwegian Seveso establishments has also been collected.

Literature study – information from regulatory authorities

Information about similar work internationally proved not to be readily available online. Therefore, DSB's contact network was used as a gateway to provide this overview. The focus was especially on other countries' development and use of indicators for establishments that fall under the Seveso II Directive, particularly as seen from a regulatory perspective. Authorities in the following countries were contacted: Great Britain, Italy, France, Germany, the Netherlands, Belgium, Sweden, Denmark and Finland. In addition, SINTEF's contacts in ETPIS, EU-Vri and the on-going EU project iNTeg-Risk² were used. The literature review is documented in Section 4.2 and in Appendix A.

² ETPIS – European Technology Platform for Industrial Safety; EU-VRi – European Virtual Risk Institute; iNTeg-Risk - Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks.

Workshop with international participation

A workshop with international participation was organised by DSB in Tønsberg, Norway 30 January 2013. The workshop had the following participation (see Appendix B):

- Authorities: Health and Safety Executive, HSE (Great Britain), Tukes (Finland), DSB and the Petroleum Safety Authority Norway (PSA)
- Two Norwegian Seveso establishments (chemical processing industry)
- SINTEF

Key items from the presentations from HSE, Tukes and PSA, together with results from the literature review have been documented in Section 4.2. Contributions from the two Seveso establishments are presented together with other information received from Norwegian companies (see Section 4.4). The presentation from SINTEF is given in Appendix B, while the input from DSB is considered to be integrated into the report in different ways, and is thus not specifically referred to in this section.

Data collection from DSB

A review of existing information available from DSB has been done (see Section 4.3). This information is assessed for relevance to the monitoring of safety level development in and around Seveso establishments.

Data collection from Seveso establishments (chemical processing industry)

To check the relevance for Seveso establishments, we made a compilation of information on the use of indicators in establishments in the chemical processing industries (see Section 4.4 and Appendix D). Two of the companies were also represented at the workshop.

4.2 Information from regulatory authorities

The authorities of nine European countries were asked to submit information/ material about their practice and on-going work regarding:

- 1) *Which indicators are used* for follow-up of risk related to sites covered by the Seveso II Directive
- 2) Experiences with respect to the process of *developing* indicators
- 3) Experiences related to the *use and development* of indicators in the regulatory activity

Appendix A provides an overview of relevant practices in different countries, including information from the Petroleum Safety Authority Norway (PSA) obtained at the workshop. A summary is given below.

Great Britain: Health and Safety Executive (HSE)

The following registrations are relevant as safety indicators for Seveso sites:

- *Hazard score*, giving a risk classification of the site with respect to safety of persons and environment. The total score is based on:
 1. Risk-potential/base score ("intrinsic hazard"), and
 2. Various "correction factors" (or "modifiers") for safety/environment

This results in a classification of the sites in four safety groups (A-D). This approach is the basis for the risk classification method suggested in Chapter 6 below (cf. Part 1 in the methodology recommended in Chapter 3).

- *Inspection score*, based on evaluations/findings made during inspections, so that trends can be registered and investigated. This score results in six groups, from unacceptable to exemplary. The HSE system is based on a number of "strategic topics" in safety management, e.g.:

1. Competence
2. Emergency planning (internal/external, "on-site"/"off-site")
3. Process safety performance indicators
4. Overfill protection/containment, e.g. of poisonous substances
5. Ageing of technical installations
6. Follow up actions after the Buncefield accident

This score system has similarities with a corresponding system used by Tukes (Finnish Safety and Chemicals Agency) described below; see Part 2 in the suggested methodology given in Chapter 3.

- *COMAH-related incidents and dangerous occurrences*. All COMAH (Seveso II) sites shall report these to the Competent Authority (HSE, Environment Agency and SEPA). Such incidents are reported to the European Commission (EC) if they meet the criteria established by the Seveso II Directive.
- *Injuries, diseases and dangerous occurrences*. The reporting is regulated by *RIDDOR*: "Reporting of Injuries, Diseases and Dangerous Occurrences Regulations" and *all* workplaces in Great Britain shall report these to HSE.
- *Incident causes*. HSE has a system in place to periodically review causes of reported incidents. This includes the analysis of failures of different barriers to loss of containment.

Italy: Ministry of Environment/ Regional Agencies for Environmental Protection (ARPA)

The regional agency for environmental protection (ARPA) in the Piedmont region collects performance indicators of Safety Management System (SMS). These are developed on the basis of the main SMS issues defined in Annex III of the Seveso III Directive and cover:

- Organisation and personnel
- Major hazards (identification and analysis/evaluation)
- Operational control and management of change
- Planning for emergencies
- Audit review

Performance indicators are used in combination with incident investigations in order to measure and evaluate the achievements to meet the objectives set in the policy for preventing major accidents.

France: Ministry of Ecology, Sustainable Development and Energy Direction

Since 1992 France has collected all accidents and incidents that adversely affect (or could affect) a serious threat to human health, public safety, agriculture, nature and environment. This ARIA (Analysis, Research and Information on Accidents) database collects information about, and catalogues the incidents, and data are continuously updated and analysed. The French Ministry of Ecology at *BARPI* (*Bureau for Analysis of Risks and Industrial Pollution*), annually issues a summary of the industrial accidents with information about e.g. type of accident, causal factors and circumstances around the accident. The results are presented as incident indicators and KPIs (Key Performance Indicators).

Germany: The Federal Environment, Labour and Internal Affairs Ministries

Safety performance indicators are not widely used by German authorities. In some cases, where presented by a company, they may be used to understand a company's performance – where the facts match these indicators. There is no assessment of national risk levels and trends for Seveso risk using indicators.

The Netherlands: Ministry of Social Affairs and Employment/ Labour Inspectorate and Ministry of Health, Welfare and Sport/ National Institute for Public Health and the Environment (RIVM)

Initiative is taken to develop safety indicators used to monitor the performance of Seveso sites, and there is a report in Dutch (with an *Abstract* in English): *Veiligheidsprestatie- indicatoren voor het veiligheidsbeheers-systeem van BRZO-bedrijven* (Bellamy et al., 2012a). (English translation: Safety Performance Indicators for Safety Management at Major Accident Sites). Safety indicators should provide information about the safety performance of the facility; it should play an important role in the communication and should indicate how well the safety management system of the facility works.

It is carried out an extensive literature survey about safety performance indicators to support the control with major accidents (Bellamy and Sol, 2012). The choice of indicators should be based on a list of 30 criteria. For example, the indicator should have a causal link with the risk. In total, the indicator set should be sufficient in number and frequency to be able to identify trends with respect to risk. In addition, concrete actions on the indicators may be attached, such as improvement interventions. Appendix F gives the list of criteria from the summary of this report, providing important aspects on how to establish and use safety performance indicators.

A first set of indicators is formulated, based on the literature survey and information from the companies, including 12 enterprises under the "Major Accident Risk Decree" (BRZO), 1999. In the next phase it will be investigated whether this set of safety indicators satisfy the chosen criteria and whether they correspond to indicators already developed by the companies. One will also look at how this can be useful for the *Labour Inspectorate*. The indicators developed will become mandatory for the companies as part of the implementation of the Seveso III Directive.

Furthermore, there is written a paper on the use of accident/incident data related to performance indicators for major accidents (Bellamy et al., 2012b). This describes e.g. a tool, "Storybuilder" for analysis of direct and underlying causes to *Loss of Containment (LOC)* accidents.

Belgium: The Federal Labour Inspectorate (Federal Public Service Employment)/Regional Environmental Inspectorates

A risk classification within an industrial complex is carried out with respect to hazard for fire, explosion and acute release of toxic substances (use of *ILO rapid ranking*). Three danger categories are used. This classification determines the minimum Seveso inspection frequency. The Federal Labour Inspectorate uses the inspection results to monitor a limited set of necessary measures (level of protection indicators) to see if these measures are implemented (or decided to be implemented). The inspection plan covers all those topics, but this is purely an *internal monitoring* system and not meant to measure the "level of risk".

Sweden: Swedish Civil Contingencies Agency (MSB)

It appears to be no (known) work with safety indicators for Seveso sites within MSB. However, IPS (*Intressentföreningen för processsäkerhet*) has worked out a report on safety indicators with focus on process safety, which gives a number of examples of typical safety indicators and criteria for use of indicators (Jacobsson and Weibull, 2010).

Denmark: Danish Ministry of the Environment

Risk indicators are not used in the regulatory work in Denmark. The Danish Ministry of the Environment is of the opinion that authorities should be careful to use risk indicators, as it is difficult to formulate indicators being suitable for comparison between enterprises, and also since the follow up from authorities is difficult if they discover that key figures behind the indicator have changed. However, some enterprises use performance indicators internally.

Finland: Finnish Safety and Chemicals Agency (Tukes)

Inspection findings are used to evaluate the safety management system of the enterprises. A grading system is developed to classify the sites based on:

- Recognition of the requirement of legislation
- Management and personnel commitment to safety
- Risk assessment and management of change
- Identification of safety requirements
 - Technical requirements and condition of equipment
 - Operating rules
 - Competence and training
- Emergency preparedness
- Impression from "safety walk" on the site

This classification is the starting point for indicators based on inspection results (see Part 2 of the methodology suggested in this report, cf. Chapter 7 below).

Furthermore, Tukes points out:

- It is important that the measuring of the functionality of safety management system works in practice.
- Both leading and lagging indicators are needed.
- Tukes are now discussing new indicators to assess both the technical safety of plants and the safety of surrounding areas.

Norway: Petroleum Safety Authority Norway (PSA)

The project *Risk Level in Norwegian Petroleum Industry* (RNNP) follows the development in risk level in the Norwegian petroleum activity, using different methods like event indicators (DSHA, *Defined Situations of Hazards and Accidents*), barrier data, qualitative studies (detailed studies for specific problem areas), working seminars, and every second year there is also issued a major questionnaire (e.g. on safety culture and perceived risk). RNNP started in 1999/2000. The work has an important position in the petroleum industry as it contributes to a common understanding among the various parties of the development in the risk level.

PSA points out e.g. the importance of indicators to be valid, reliable, sensitive, and representative, without bias and to be cost effective. The information must be available and come from different sources (both PSA data bases and enterprise data bases). A combination of leading and lagging indicators is used. PSA has good experience with the work, which is based on a "tripartite cooperation" (authorities, employers and employees), and various forums are established, (e.g. a reference group, advisory group and a safety forum).

The information from the risk level project gives a valuable insight related to important traits in the industry development; hence it constitutes a valuable part of the risk based foundation that PSA supervisory activities are based upon.

Some advice:

- Start from what the industry already has of registrations related to indicators. Start with a small number of indicators, and then build on this. It is important not to burden the industry with unnecessary registrations.
- The method must be acceptable for the industry, so that one can focus on results and not use energy on criticizing the method.
- Focus on operational safety in the first phase.
- Develop indicators that are easy to communicate. Indicators must reflect what is intended to be measured, and they must be adapted to the phenomena (i.e. actual accident scenarios).
- RNNP is seen as a key instrument for communication to create interest in the industry for topics that are important regarding safety. It is important to get the industry involved, create various arenas (meetings, seminars) to discuss results and challenges which the industry has to work with.
- Have patience and work on a long term; it will take at least four years until one can start evaluating trends.
- The experience with introduction of indicators for land facilities shows that there is a need for barrier indicators in addition to event indicators (DSHA).
- Data quality can be a problem (avoid that this changes the conclusions).

Information from authorities – concluding comments

The review and summary of corresponding work internationally show that regulatory authorities in most countries have routines for some kind of risk registration. The methodology of HSE (*Site prioritisation methodology*) describes e.g. how to calculate the risk potential for various sites in a systematic way, both with respect to personnel and surroundings/3rd party, i.e. an evaluation of "built in hazards/risks" in the enterprise.

The practices around the development and use of indicators are varying. In some countries indicators are used for monitoring safety level development of a site or an industry. In some cases authorities use indicators in their regulatory work. Tukes in Finland uses a measuring system to evaluate the quality of elements in safety management of the enterprise, based on results from inspections, but has of today not indicators for measuring technical and operational conditions. In the Netherlands it is taken an initiative to develop safety indicators which shall be used to monitor the performance of Seveso sites. A first set of indicators is formulated, based on a survey of scientific literature and information from the industry.

In Great Britain traditional safety indicators are not used by HSE. However, the authorities are measuring how far the enterprises themselves have come in the process of developing and implementing indicators relative to a four step process. In Sweden it seems to be no ongoing work on safety indicators for Seveso establishments within MSB. However, in the industry there is a developing work carried out by "Intressentföreningen för processsäkerhet" (IPS, an association for process safety).

The Petroleum Safety Authority Norway is the authority which has the longest experience in developing and using indicators in monitoring trends in risk/safety level. PSA considers RNNP as an important communication tool to create interest in the industry for topics being important with respect to safety. It is essential to get the industry as a team player, and create various arenas (meetings, seminars) to discuss the results and the challenges which the industry has to work further on.

The following work with developing a methodology for monitoring safety trends in and around Seveso establishments is mainly based on experiences from HSE (Great Britain), Tukes (Finland) and the Petroleum Safety Authority Norway.

4.3 Review of existing information available from DSB

Existing/ available information from DSB has been reviewed, and it has been assessed whether, and if so, how this information could be used for periodic monitoring and evaluation of safety trends. The following information is reviewed:

- Total inspection results of various topics, that go back several years (from 2005)
- Summary of inspection results for individual establishments, subject to the National Seveso Regulation
- Registrations of the fire brigades' emergency responses to events at Seveso establishments
- Registrations of incidents at Seveso establishments
- Survey of municipalities' external emergency related to events in Seveso establishments

From the reviewed material, the overall inspection results dating back to 2005, was considered as most interesting. Therefore, a systematisation of this information was carried out.

Number of nonconformities and observations for various topics and years (2005-2011)

In Appendix C, it is given an overview of the overall inspection results in the period 2005-2011, based on the annual reports of the Seveso Coordinating Committee for the National Seveso Regulation. In the annual report for 2011 the nonconformities and observations from inspections are distributed amongst 12 different topics. In Table 1, it is also added a topic 13 (taken from the annual report of 2005, but this appears to be used only this year).

Table 1. Review of nonconformities and observations for various topics at inspections carried out according to the National Seveso Regulation (2005-2011).

No.	Description of topic	Non-conformities	Observations	SUM
1	Documentation and management system (incl. documentation of explosion protection)	198	255	453
2	Technical deficiencies (incl. management deficiencies until 2009)	78	122	200
3	Maintenance and condition monitoring (from 2010)	8	21	29
4	Evaluation and documentation of risk	91	99	190
5	Emergency preparedness and training	46	62	108
6	HSE procedures related to the National Seveso Regulation	39	68	107
7	Education and training (from 2007)	29	36	65
8	Treatment of nonconformities (from 2007)	20	49	69
9	Internal audits and monitoring (from 2007), incl. "Other" (2006/2007)	18	20	38
10	Safety reports	11	16	27
11	Responsibilities and organisation	4	26	30
12	Information to the public	17	24	41
13	Warning and reporting (2005)	2	2	4
	TOTAL, all topics	561	800	1361

Regarding Topic 1: *Documentation and management system*, it is stated that the figures for 2009 include three nonconformities and one observation related to documentation of explosion protection. Furthermore, there have been some changes in the classification, especially from 2007:

- Topic 3: *Maintenance and condition monitoring* was a separate item from 2010; previously this was included in the Topic 2: Technical deficiencies.
- Topic 7: *Education and training* was a separate item from 2007; previously this was found under Topic 5: Emergency preparedness and training.
- Topic 8: *Treatment of nonconformities* was a separate item from 2007; previously this was found under Topic 1: Documentation and management system.
- Topic 9: *Internal audits and monitoring* was a separate item from 2007; previously this was found under a topic "Other". These two topics are merged here.

In the table in Appendix C topics that had special attention from the inspections, or was mandatory for each year, are marked with "yellow" colour (where indicated).

Number of inspections per year has remained relatively constant. The following is found:

- In 2005 there were major accident inspections at 52 establishments
- In 2006 there were major accident inspections at 57 establishments
- The reduction in the number of inspections from 2008 to 2009 is due to a large number of establishments not being supervised in 2009, cf. approved supervision plans for selected establishments. Similarly, the increase in 2010 was due to several supervision plans being expired and should be reconsidered by the authorities.

Moreover, the number of nonconformities/ observations for each topic was summarized for all years (2005-2011), to get an idea of the topics that stand out as recurring issues.

- The Topic 1: *Documentation and management system* is without comparison, the topic with the highest number of nonconformities and observations.
- If we add Topic 2: *Technical deficiencies* and Topic 3: *Maintenance and condition monitoring*, these together have the same number of nonconformities as Topic 4: *Evaluation and documentation of risk* (shared 2nd place). Topic 2 has clearly more observations than Topic 4.
- Topics 5: *Emergency preparedness and training*, and Topic 6: *HSE procedures related to the National Seveso Regulation* have nearly the same total number of nonconformities and observations (in 4th place).

Existing information available from DSB – concluding comments

Existing/ available information from DSB has been reviewed and it is assessed whether, and if so, how this information could be used in a periodic assessment of safety trends. Regarding the review of the overall inspection results for the period 2005-2011, it can be seen that most nonconformities are related to documentation and management systems. Other topics with frequent nonconformities are within technical deficiencies, maintenance and condition monitoring of equipment, as well as evaluation and documentation of risk.

Inspection results will always be determined by what is in focus and what the authorities are looking for. There is not necessarily so, that topics with most nonconformities after an inspection, are the factors that have the greatest impact on safety. Therefore we should be careful to develop indicators directly based on the inspection results, i.e. the number of nonconformities/ observations. But on a general level, i.e. in the assessment of which topics to establish indicators for, it could be some support in the inspection results.

This means that maintenance and condition monitoring of equipment, as well as evaluation and documentation of risk, are factors that should be followed up with indicators. Discrepancies related to documentation and management system are considered less relevant to use, as these indicators are difficult to measure in relation to safety.

Moreover, the overall assessment (overall impression) of safety management that the authorities get when carrying out inspections, provides important information and is the basis for Part 2 of the methodology described in this report, cf. Chapter 7.

Reporting of accidents and incidents from the Seveso establishments to DSB was also assessed with respect to whether these reports could be a suitable basis for establishing indicators. The general impression is that the information obtained through these reports is not of such a nature that it is particularly relevant. If such data should be used as the basis for developing safety indicators, the causes and circumstances that contributed to the events should be better documented.

4.4 Information from the establishments

A key assumption for the method is that it is understandable and acceptable to the industry. Therefore, it is important to use the registrations already available in the industry, to avoid burdening the establishments with unnecessary registrations. Approx. 20 companies in the category chemical processing industry were asked to provide answers to the following three questions:

1. Does your company use any type of indicators for measuring risk/safety trends?
2. Can you give examples of safety indicators you are using (e.g. injury statistics, failure of safety critical barriers revealed during test, maintenance "backlog", and frequency of safety training for operating personnel)?
3. What do you collect/ record of this type of data today?

In total, 13 companies gave feedback to the questions above. The number of companies includes the two establishments that were represented at the workshop. The information is systematised in the following categories of indicators:

- a) Outcome/ event based indicators ("lagging")
- b) Technical/ operational indicators, including the status of barriers ("leading")
- c) Organisational indicators/ SMS - Safety Management System ("leading")

Examples of indicators within each category are shown below. Detailed review is found in Appendix D.

The general impression is that the establishments to a great extent collect data and are applying indicators of the first two categories. Only 5 out of 13 companies report that they apply proactive ("leading") indicators associated with organisational factors/ Safety Management System (i.e. type c)), while 12 and 11, out of the 13 companies state that they are using indicators of category a) and b).

Furthermore, there is a big difference in terms of the number and type of indicators that each company uses. Below we list some typical examples of indicators within each category.

a) Outcome/ event based indicators

- Number/ frequency of injuries
- Number/ frequency of lost time accidents
- Number/ frequency of incidents/ near misses
- Number/ frequency of incidents involving high risk potential (HIPO)
- Number/ frequency of accidental spills of oil/chemicals, gas leaks, "loss of containment" (LOC)

b) Technical/ operational indicators

- Testing of safety system/ barriers (e.g. safety valves, gas detectors): Number of failures per number of performed tests
- Inspection of safety critical equipment (e.g. pipelines, process equipment): Number of findings per number of performed inspections
- Number/ frequency of (serious) deviations (e.g. in control procedures, or identified during safety rounds)
- Number of safety critical alarms
- Overrides: Number overrides per number of possible, critical overrides
- Required maintenance: Defective equipment, technical condition
- Maintenance "backlog" of safety critical equipment
- Engineering compliance: Percentage of overdue actions/ measures following inspections

c) Organisational indicators/ SMS - Safety Management System

- Percentage of employees/ contractors with approved safety course
- Frequency of health, safety and environment training
- Degree of safety training for contractors/ suppliers
- Degree of compliance in relation to regulatory requirements
- Percentage of closed actions/ measures following adverse events
- Percentage of safety rounds (monthly) with more than 60 % participation
- Number of complaints from neighbors

Information from the establishments – concluding comments

Approx. 20 companies in the category chemical processing industry were asked whether they use any kind of indicators for monitoring risk/safety trends. Feedback from 13 companies indicates that the establishments to a great extent are applying indicators of type a) outcome/ event based indicators and b) technical/ operational indicators, while only a minority (5 out of 13 companies) reports that they use leading indicators related to organisational factors/ Safety Management System. Furthermore, there is a big difference in terms of the number and type of indicators each company uses.

Information obtained from the companies constitutes an important background for the methodology described in Chapter 8.

5 A methodology consisting of three parts

Based on a dialogue with DSB, input from the Petroleum Safety Authority Norway, experiences and practices in other countries, plus input from the establishments, we suggest a methodology for risk classification and periodic monitoring of safety trends in and around Seveso establishments, consisting of three parts:

1. Method for ***risk classification*** of establishments
2. Method for developing safety indicators based on the ***regulators' inspection results***
3. Method for developing safety indicators based on ***data submitted by the establishments***

This comprises three different and relatively independent approaches, which do not need to be combined. An advantage is that the authorities can work with all (or two) of the approaches, and later chose to put less emphasis on one of them, without having to change the work with the other approaches.

1. Risk classification of establishments

This methodology gives an overview of the establishments' "embedded hazards/risks", both with respect to employees and 3rd party/ environment. The data basis for the method will be the information found in safety reports, registrations in the societal safety database SamBas, applications of consent and the general knowledge of the regulatory personnel. The method is based on the *Site prioritisation methodology* developed by HSE, Environment Agency and Scottish Environment Protection Agency; see HSE et al. (2010).

2. Indicators based on regulators' inspection results

This part establishes indicators based on the regulators' overall impression of the Safety Management System when carrying out inspections at the various establishments. This approach is based on a set of systematic evaluations, and is rather similar to methods used by Tukes and HSE.

3. Indicators based on data submitted by the establishments

Indicators that will give an overall picture ("measure the temperature") of the state of Seveso establishments in Norway will be suggested as a basis for prioritisations made by National Seveso Authorities. This approach is rather similar to the work carried out by the Petroleum Safety Authority Norway in the RNNP project.

Approaches 1 and 2 will be particularly relevant for the planning of regulatory activities and for comparisons of establishments. Further it will form an important basis for evaluating the development of risk to the surroundings/3rd party caused by the Seveso establishments.

Approaches 2 and 3 will form a useful basis for providing the overall picture of the state of Norwegian Seveso establishments, and for the follow up of risk trends.

The various methods will be further described in Chapters 6, 7 and 8.

6 Risk classification of establishments

As a first step in the efforts to establish safety indicators it is proposed to perform a risk classification of the various establishments, i.e. an evaluation of "embedded hazards/risks" in the establishments, both with respect to employees and surroundings/3rd party. The risk classification is characterised by:

- The risk classification will be relatively static because it depends on the establishment's activities and location, and such factors do not change much over time.
- There will be a categorization of "hazard category" and "establishment type", as a basis for a score system.
- The basis for the evaluation will be safety reports, applications for consent, the societal safety database Sambas and the general knowledge of the regulatory personnel.

6.1 Score system for risk classification

The risk classification of establishments presented here is based on the *Site Prioritisation methodology - Intrinsic Hazard (Safety and Environment) and Performance* (HSE et al., 2010). Changes relative to this approach comprise that we choose to split the risk into three contributions: 1) The onsite (internal) risk of the plant, 2) the offsite (external) risk and 3) the environmental risk. Here HSE rather splits the risk into two

parts only: the environmental risk and "other" risk. Another difference is that we also include the transfer of risk to other industry/establishments in the surroundings. Finally, the calculation of environmental risk is simplified relative to the method used by the HSE. The proposed method consists of the following five steps:

1. Establish a list of *possible hazards*
2. Specify *types of establishments*
3. Determine a *base score* for the different establishment types
4. Determine the values of various *correction factors* (employees, population, institutions/ infrastructure, industry/ establishments)
5. Calculate the *total risk score* (see Section 6.2)

Establish a list of possible hazards

First, establish a list of relevant hazard categories related to the establishment's activity. This will for example be:

- Flammable substances
- Explosives
- Toxic substances
- Other

Specify types of establishments, and determine the base score

For each hazard category, we specify the different types of establishments, which are given different base scores, R0 and E0.

- **R0** is a base score of *establishment risk*, including risk to persons and assets
- **E0** is a base score for the *environmental risk*

The values of the base score for the establishment risk, R0 are taken from the "HSE methodology". Regarding the environmental risk, we only use a base score, E0 without correction factors. For this reason the E0 values are chosen twice the base scores suggested in the "HSE methodology". So, in the present report a simpler method is chosen than the one suggested by HSE, which in addition to the base score for environment introduces two correction factors ("sensitivity modifier" and "pathway modifier", respectively). If one decides also in Norway to apply a more advanced model for environmental risk, it is referred to the classification model developed by the Climate and Pollution Agency (Klif, 2011).

To give an *example* base score we look at the category *flammable substances*, where for various types of establishments give base score, **R0** with respect to establishment risk, and **E0** with respect to environmental risk:

- Petrochemical processing, incl. refining (R0 = 8; E0 = 18)
- Chemical manufacturing sites with bulk storage of flammable liquefied ids (R0 = 3; E0 = 16)
- Gas terminals (R0 = 6; E0 = 14)
- Bulk fuel storage (R0 = 3; E0 = 14)
- LPG bulk storage and distribution (R0 = 3; E0 = 2)
- LPG bottling (R0=4; E0=2)

See also Table 2, where some hazard categories and establishment types are filled in as an example.

Determine values of the various correction factors

The overall establishment risk score (environmental risk excluded) is determined from R0, plus a number of other conditions that are relevant with respect to possible events that can happen on the site. These conditions determine the value of some *correction factors*, R1, R2, R3 and R4, where:

- **R1** is a measure of risk exposure with respect to the life/health of *employees* in the company ("onsite"). This is measured in terms of the basic staffing at the establishment.
- **R2** is a measure of the risk for life/health of the residents in the surrounding buildings ("offsite"). This is given from the *population* size in the surrounding area, i.e. within a safety zone of e.g. 300 meters.
- **R3** is a measure of the risk for surrounding *institutions/ infrastructure* (societal risk). This includes risks related to public buildings/ infrastructure (i.e. buildings and areas used by many people at the same time, such as schools, health institutions, shopping centres, sports venues, main traffic roads).
- **R4** is a measure of the risk for surrounding *industry/ establishments*.

Also for the correction factors there are indicated numerical values that are quite close to the "HSE methodology" (HSE et al., 2010). For the employees and population factors (R1 and R2), we use (as for the population factor in the "HSE methodology") four categories, and altogether the numerical values of R1 and R2 are of the same magnitude as the population factor of HSE (even if the border between *large* and *medium* population are not identical). Regarding the correction factor, R3 (institutions/ infrastructure), we use, as in HSE, only two categories; the suggested values being 0 and 2. The factor R4 (industry/ establishment) is not used at HSE, and here we use two categories, as for R3. As an *example* the following correction factors are given:

- *Risk for employees in the company (internal/"onsite"), factor **R1**:*
 - Large staffing (> 50): R1 = 6
 - Medium staffing (5-50): R1 = 4
 - Small staffing (< 5): R1 = 2
 - No staffing: R1 = 1 (i.e. only risk to assets in the business).
- *Risk for population (residents close to the business) (external/"offsite"), factor **R2**:*
 - Large population (> 500): R2 = 12
 - Medium population (50-500): R2 = 6
 - Small population (1-50): R2 = 3
 - No population: R2 = 1 (R2 is not given a value of 0, because there could be people in the area, though no one lives there permanently).
- *Risk for institutions/ infrastructure, factor **R3**:*
 - The establishment is located on a site with such risks, R3 = 2; otherwise R3 = 0.
- *The risk for spreading to industry/ establishments, factor **R4**:*
 - The establishment is located on a site with a risk of such spread: R4 = 2; otherwise R4 = 0.

The different scores and the correction factors are also given in Table 2. Note that the numeric values are primarily intended as an illustration. Considerable work remains to balance and weigh them against each other in a good way.

6.2 Calculation of the total risk score

Figure 2 summarizes the calculation of an overall risk score (red box). The risk is split into an *establishment risk* (yellow boxes), which includes personal risk and risk to assets, and an *environmental risk* (green boxes).

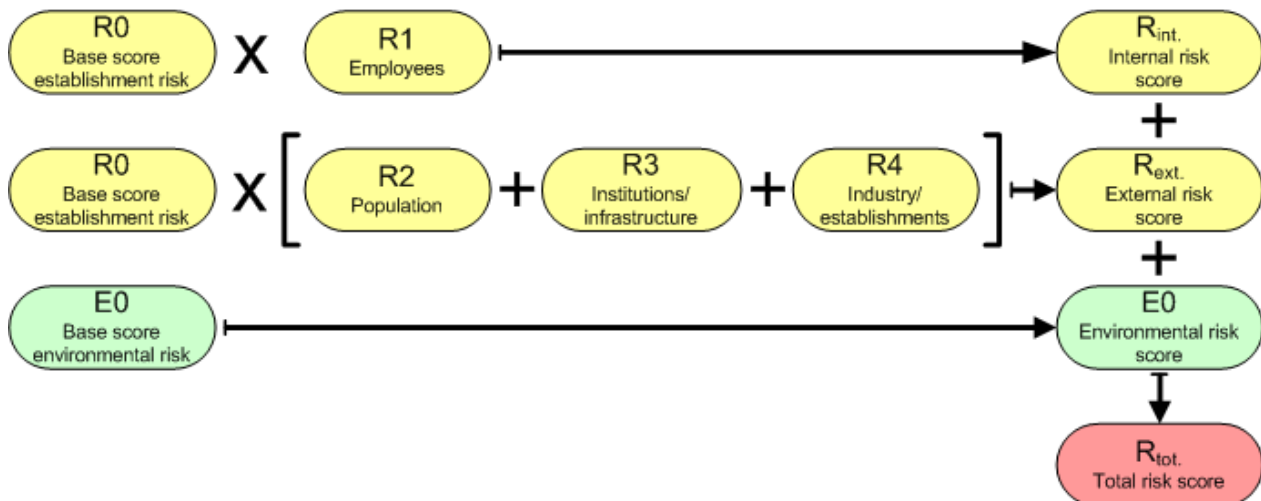


Figure 2. Calculation of the total risk score. (Model inspired by HSE et al., 2010).

The establishment risk score is further split into an internal and external score. The *internal* risk score is given by the base score, R0, being multiplied by a correction factor, R1; i.e. the internal risk score is defined as:

$$R_{\text{int.}} = R_0 \times R_1$$

The *external* risk score is given by the base score for establishment risk, R0 multiplied by the sum of the correction factors, R2, R3 and R4, that is:

$$R_{\text{ext.}} = R_0 \times [R_2 + R_3 + R_4]$$

Note that the factors R2, R3 and R4 represent three completely different contributions to the risk; i.e. $R_0 \times R_2$ represents the risk for the population in the neighbourhood of the establishment, $R_0 \times R_3$ is the risk score for institutions/ infrastructure, and $R_0 \times R_4$ provides the risk score for possible other industry/ establishments. These three contributions should be summed to obtain the total "external risk score", and therefore we take the sum $R_2 + R_3 + R_4$, before multiplying with the base score. This differs slightly from the "HSE-methodology", which utilizes a pure multiplicative model to estimate the "establishment risk".

Moreover, the environmental risk score equals E0, and thus the *total risk score* becomes:

$$R_{\text{tot.}} = R_{\text{int.}} + R_{\text{ext.}} + E_0$$

6.3 Use of this risk classification

By calculating the total risk score for the establishments, we also obtain a risk classification of these. The authorities will get an overview of the distribution of scores for all establishments, and can e.g. group the establishments into different categories, e.g. a category with score < 100 , a category with a score > 100 , but < 200 , etc.

Basically, this classification is fixed and can e.g. be performed in connection with the process of application for consent. But if the establishment carries out changes - or if there are changes in the environment - resulting in new values of R0, R1, R2, R3, R4 or E0, the classification must be updated. So in a certain sense this works as a risk indicator. As an example you can follow the overall risk score for all establishments that are subject to the National Seveso Regulation, or record the number of establishments that fall into the different score categories. Another way to use the risk classification is to follow the development (trends) of safety indicators for each scoring category; for instance considering the trend of a safety indicator, restricted to establishments with a high total risk score.

Table 2. Score system for risk classification of establishments (numerical values are given for illustration only).

Hazard category	Establishment type	Base score, establishment risk, R0	Correction factors for risk			Internal risk score, $R_{int.} = R0 \times R1$	External risk score, $R_{ext.} = R0 \times [R2 + R3 + R4]$	Environmental risk score, E0	Total risk score, $R_{tot.} = R_{int.} + R_{ext.} + E0$
			Employee factor, R1	Population factor, R2	Institution/-infrastructure factor, R3	Industry/establishment factor, R4			
Flammable substances	Petrochemical processing, incl. refining	8	Large staffing (> 50): R1=6	Large population (> 500): R2=12	Location causes societal risk: R3=2, otherwise R3=0	Location causes risk of spreading to other industry: R4=2, otherwise R4=0		18	
	Chemical manufacturing sites with bulk storage of flammable liquids	3	Medium staffing (5-50): R1=4	Medium population (50-500): R2=6				16	
	Gas terminals	6						14	
	Bulk fuel storage	3						14	
	LPG bulk storage and distribution	3						2	
	LPG bottling	4	Small staffing (< 5): R1=2	Small population (1-50): R2=3.				2	
Explosives	Explosive storage	5	No	No				2	
Toxic substances	Manufacture of liquefied toxic gases	10	staffing: R1=1	population: R2=1				18	
	Chemical manufacturing sites with bulk storage of liquefied toxic gases	8						16	
Other									

7 Indicators based on regulators' inspection results

Part 2 of the proposed methodology is based on the regulators' overall impression of the establishment's safety management system related to findings from inspections. This approach is very close to the assessment carried out by Tukes and HSE. Especially Tukes has developed a detailed evaluation model based on findings made during inspections. The establishment's location and operation is specified, and it is then assessed with respect to (based on Tukes, 2013):

- a) Compliance with regulatory requirements
- b) Management and personnel commitment to safety
- c) Risk assessment and management of change
- d) Technical requirements and condition of equipment
- e) Operating instructions
- f) Competence and training
- g) Emergency preparedness
- h) On-site tour

A further, more specific point may be relevant in connection with the process of introducing indicators:

- i) Assessment of the level of maturity in relation to the development and use of indicators (HSE et al., undated).

These conditions can provide several indicators, or an overall indicator. Tukes uses a 6-point scale to assess each of the steps a) - h), or a) - i) listed above, to give an overall "score" (rank); see Table 3.

Table 3. Ranking based on findings from regulators' inspections (based on Tukes, 2013).

Ranking	Evaluation	Comment
1	Best practises	Encouraged to continue proactive development
2	Good practises	Positive features identified
3	Meets legal requirements	Possibilities for development emphasised
4	Requires improvements	Advised, urged to improve
5	Significant deficiencies	Swift action required
6	Severe deficiencies	Immediate action required

Note that the scale in the above table is inverted relative to Tukes' scale. The reason for this is to harmonize with the methodology described in Chapter 6, where a higher "score" means higher risk.

As a basis for the ranking there is developed a "maturity scale"/ performance standard for each point a) - h) above. As an example of how the rankings can be implemented in practice, Tukes indicates a rating of point c) *Risk assessment and management of change*. The following characteristics apply to the different maturity levels:

1. Risk assessment covers all aspects of operations and is also expected of the sub-contractors. Some innovative methods, practices, etc. setting the company apart from those at rank 2.
2. Hazard identification and risk assessment are an integral part of the daily operations of the plant. Methods used are versatile and complements one another, e.g. instructions systematically developed, based on the results from regular assessment updates.

3. Systematic hazard identification and risk assessment. Results directly affecting e.g. maintenance, training, operating instructions and procurement of new equipment. Potential off-site consequences of major accidents identified.
4. Risk assessment using only one method (e.g. HazOp). Results do not affect decision-making. Assessments not updated.
5. Hazards identified at a very basic level. No risk assessment.
6. Hazards not identified at all.

When all the points a) - h), or a) - i) are evaluated from such a taxonomy, one can calculate an average of the ratings, to provide an overall assessment of safety management in the establishment. This average value - or the ranking of a particular topic - would represent a safety indicator for each establishment.

By taking the average ranking(s) for all, or a group of Seveso establishments, the authorities in this way get several safety indicators for the general level of the safety management. Tukes also proposes to calculate the fraction (%) of establishments getting a value ≤ 3 (in the scale 1 - 6), and has formulated a goal that this fraction should be at least 50 %.

8 Indicators based on data submitted by the establishments

8.1 Approach for selection of indicators

In Part 3 of the proposed methodology, indicators based on measurements and submission of data by the establishments are developed. The indicators should provide an overall picture of the condition of Norwegian Seveso establishments as a basis for future prioritisations for the National Seveso Authorities. This approach builds on experiences from PSA's work with RNNP (Risk Level in Norwegian Petroleum Industry). The following main categories of indicators are proposed:

- a) Outcome/ event based indicators ("lagging")
- b) Technical/ operational indicators, including the status of barriers ("leading")
- c) Organisational indicators/ SMS – Safety Management System ("leading")

In the first phase of the work, we recommend to start implementation of indicators for one sector. The suggestions given in this report are adapted to the chemical processing industry. After a test period it should be considered to expand the use of indicators to cover all sectors that fall under the National Seveso Regulation. In the long term the indicators could be divided into two groups: 1) *Generic indicators* that will apply to all establishment types; and 2) *Specific indicators* that will apply to establishments within a particular category (e.g. bulk storage facilities (liquid), gas storage, explosive storage, explosive manufacturers and chemical processing industries).

Indicators proposed in the first phase are based on factors that are assumed to be important for safety, without any grounding in a specific risk model. We would include indicators from all major categories a) - c), but the focus will be on outcome/ event indicators and technical/ operational indicators. When it comes to outcome/ event indicators, fires, explosions, emission to air and discharges to water/soil will be most relevant. The suggestions have been adapted in the relation to the feedback from the companies (see Section 4.4).

Further criteria for the selection of indicators in phase 1 are:

- Should generally be based on what the industry already know/ is familiar with, or is using today, and should not require too much additional effort by the industry for registration and measurements
- Good availability of reliable/ valid data

- Focus on major accident potential
- Will contribute to improved safety

Regarding practices in the use of safety performance indicators in chemical processing industry, we refer to Appendix D, which provides an overview of feedback from 13 companies.

8.2 Proposed set of indicators

Initially we suggest to start with a small number of indicators (here six), which covers all the categories a) - c). Some of the proposed indicators are based on the frequency of events (cf. DSHA) and the reliability of barriers. In order to get enough data, and also take into account that the companies are very different in type and nature, the events are not very specified. This is a main difference compared to the indicators used in RNNP.

The proposed indicators presented in Table 4 are considered to be a selection of the most frequently used indicators that emerged from the survey of the companies.

Table 4. Proposed indicators based on data submitted by the establishments.

No.	Indicator	Recorded by the companies today?	Type of indicator	"Generic" vs. "specific" indicator ³	Comments
1	<i>Number/frequency of accidents of four event types:</i> <ul style="list-style-type: none"> • fire • explosion • emission to air • discharges to water/soil 	To a large extent	Outcome/-event based (a)	Generic	May also be combined into one indicator. Data is believed readily available and therefore seems suitable for phase 1.
2	<i>Number/frequency of near misses/incidents with a potential of a major accident risk (fire, explosion, emission to air or discharges to water/soil)</i>	To a large extent	Outcome/-event based (a)	Generic	Implies that all events will be assessed from such a potential. Requires that the industry makes a detailed assessment of their events (i.e., possible additional work), but it will hopefully be perceived as a useful "drill".
3	<i>Relative number of failures in safety critical barriers (during testing)</i>	To some extent	Technical/-operational (b)	Specific	Assumes that the company has defined safety critical barriers. This will however be a useful review.

³ *Generic indicators* should apply to all types of companies, while *specific indicators* should apply to a particular category of companies.

No.	Indicator	Recorded by the companies today?	Type of indicator	"Generic" vs. "specific" indicator ³	Comments
4	<i>Recorded active overrides (at a given time each week)</i>	To some extent	Technical/-operational (b)	Specific	Assumed to provide a risk picture of certain types of incidents with major accident risk potential. May represent additional work for some companies, but not extensive. To be perceived as a useful overview.
5	<i>Maintenance backlog on safety critical barriers (hours)</i>	To a large extent	Technical/-operational (b)	Generic	The maintenance backlog provides early warning of potential increase in the risk of major accidents. This indicator is one of several maintenance indicators introduced by the PSA in RNNP.
6	<i>Incident reporting closing rate (percentage of closed measures after adverse events)</i>	To a lesser extent	Organisational (c)	Generic	Data is assumed readily available.

The proposed indicators should be specified in a dialogue with the industry, and each indicator should be specified in a form or a fact sheets that may contain information about:

- Indicator number and name
- Definition of the indicator
- Description of the indicator
- Data sources for obtaining the necessary information to calculate the indicator
- Responsible to collect, analyse and report data and information
- Registration and calculation of the indicator
- Acceptance criteria (applies to those indicators where this is relevant)
- Evaluation and justification of the indicator with respect to relevance and quality
- Comments and references
- Last revision date

A sample fact sheet is shown in Appendix G.

9 Synthesis and use of results

It is suggested to develop a methodology for risk classification and indicators for periodic monitoring of safety trends in and around Seveso establishments. The approach will consist of the following three elements:

1. Risk classification of the establishments
2. Safety indicators based on the regulators' inspection results
3. Safety indicators based on data submitted by the establishments

This comprises three different and relatively independent approaches, which can be used either in combination or independent of each other.

Part 1 provides a risk classification that includes both internal and external risks to people and assets (R_{int} and R_{ext}), as well as environmental risk ($E0$), cf. Table 2. These three scores can then be summed to a total score, $R_{\text{tot}} = R_{\text{int}} + R_{\text{ext}} + E0$. This provides a relatively stable classification of the establishments, which has to be reviewed only if there are changes in the conditions at, or around the establishment.

Parts 2 and 3 represent the traditional safety indicators, which are monitored/ updated e.g. on an annual basis. When it comes to safety indicators based on the inspection results, a total of nine indicators are proposed. They relate to factors such as *compliance with regulatory requirements*, *management commitment* and *competence and training* (see Chapter 7). These indicators can be used either separately or also combined (taking an average) to give an overall rating of the safety management system. A six-point scale is proposed for these indicators.

The proposed safety indicators, based on data submitted by companies, are frequency of various events, test results, maintenance backlog and the extent of closed measures (see Chapter 8). It has been an intention to cover all three categories of indicators:

- a) Outcome/ event based ("lagging")
- b) Technical/ operational, including the status of barriers ("leading")
- c) Organisational/ SMS - Safety Management System ("leading")

Only one of the six proposed indicators is of category c) *organisational*; however, the indicator(s) based on the regulators' inspections (i.e. Part 2 of the methodology) are also organisational. Therefore, it is considered to be a good balance between the three indicator categories.

An overview of the elements of the methodology is presented in Table 5 (without any details being given).

A key assumption of the method is that it should be easily understood and accepted by the industry. Furthermore, it is important not to burden the establishments with unnecessary registrations. Therefore the indicators for Part 3 of the methodology are based on the current registrations made by the industry.

Regarding the number of indicators, it is generally advised to start with a small number of indicators, and so gradually increase the number of indicators. It is therefore an open question whether it is sensible to start with the introduction of all three elements of the methodology simultaneously. Regarding Part 3, where implementation requires particularly close cooperation with the industry, it is considered that six indicators is an acceptable number, but one can of course also start with a lower number of indicators.

Table 5. Suggested overall table for risk classification and safety indicators.

Establishment type	1. Risk classification				2. Safety indicators, inspection results					3. Safety indicators, data submitted by establishments					
	R _{int.} Inter- nal score	R _{ext.} Exster- nal score	E0 Environ- mental score	R _{tot.} Total score	a)	b)	i)	Average	1	2	3	4	5	6
Petrochemical processing, incl. refining	<i>Example:</i>				Ranking: 1-6					Number/frequency of various events, backlog, extent of closed measures ...					
	32	64	18	114											

Here is given an example of the two first elements of the methodology (cf. information in Table 2 and Table 3 above).

1. Risk classification:

The example is for establishment type: Petrochemical processing industry incl. refining:

$$\begin{aligned}
 &\text{Base score for establishment risk:} && R_0=8 \\
 &\text{Employees factor:} && R_1=4 \\
 &\text{Population factor:} && R_2=6 \\
 &\text{Institution/infrastructure factor:} && R_3=0 \\
 &\text{Industry/establishment factor:} && R_4=2 \\
 &\text{Base score for environmental risk:} && E_0=18 \\
 &&& R_{\text{int.}} = R_0 \times R_1 = 8 \times 4 = 32 \\
 &&& R_{\text{ext.}} = R_0 \times [R_2 + R_3 + R_4] = 8 \times [6 + 0 + 2] = 64 \\
 &&& E_0 = 18 \\
 &&& R_{\text{tot.}} = R_{\text{int.}} + R_{\text{ext.}} + E_0 = 32 + 64 + 18 = \underline{\underline{114}}
 \end{aligned}$$

2. Safety indicators (ranking) based on inspection results:

- a) Compliance with regulatory requirements: 3
 - b) Management and personnel commitment to safety: 2
 -
 - i) Level of maturity with respect to development and use of indicators: 4
- Average: 3**

10 Way forward

The report provides a suggested approach for risk classification and selection of risk/safety indicators for Seveso establishments. This can be considered as a first step in an effort to develop and implement a methodology for periodic monitoring and evaluation of safety development in and around establishments that handle large amounts of hazardous chemicals. Considerable work remains first to select the indicators one will pursue in the initial phase, and further to develop the methodology and the number of indicators as experience is gathered. There is a need for a multidisciplinary approach and a coordinated operation between regulatory authorities and establishments, possibly assisted by research institutions and others.

First, one should consider whether to initially go for a development of all the three elements of the methodology in parallel, or if one will prioritise. As the three parts are relatively independent of each other, there seems to be no problem to phase in the elements gradually (one by one).

The challenges ahead for the three elements of the methodology are somewhat different. When it comes to risk classification (Part 1), it is the model for the calculation of risk score which seems to be the main challenge. Regulators must decide whether the proposed *division of risk into three parts (internal and external establishment risk and environmental risk)* is desirable, and whether the right base scores and correction factors are chosen. The calculation formula should also be considered. Furthermore, the quantification of the base scores and correction factors represent a challenge. It will require a significant effort in order to feel confident that these balance the resulting risk score in a good way. The methodology also requires that one first defines and carries out a classification of establishment types. Though having the "HSE-methodology" as an example/ starting point, this work seems to be relatively resource intensive.

As for Part 2, indicator(s) based on the inspection results, a much simpler system for quantification is suggested, and it is believed that the authorities - based on the experiences from Tukes and HSE - will be able to establish such a methodology without too much effort. But it is necessary that data collection is accommodated into the inspection tasks. It also seems that this element in the methodology can be implemented without requiring significant efforts from the establishments.

Part 3, indicators based on data submitted by the establishments, will however require a close collaboration with the industry, and a process leading to a gradual introduction (and subsequent increase in number) of such indicators should be planned. Topics that should be included in such a plan are:

- The industry should be encouraged to provide feedback on the proposals in this report, and further dialogue must be maintained
- One should identify any need for additional data collection/ detailing of reported incidents to authorities (including causes), as a basis for good outcome/ event indicators
- The use of indicators should be further discussed. For instance, should limits for "acceptable" values ("alarm limits") be established?
- There should be a plan to extend/ modify the list of indicators
- It should develop forums for discussion of findings/ actions; similar to those arenas created under the auspices of *Risk Level in Norwegian Petroleum Industry* (RNNP).

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Appendices

- Appendix A: Summary – literature review
- Appendix B: Workshop in Tønsberg 30 January 2013
- Appendix C: Annual inspections results (nonconformities and observations)
- Appendix D: Safety performance indicators - data provided by the establishments
- Appendix E: The OECD guidance on developing safety performance indicators
- Appendix F: Important aspects for the design and operation of a safety performance indicator system (The Netherlands)
- Appendix G: Sample fact sheet – safety performance indicators
- Appendix H: Abbreviations

Summary – literature review

Summary – literature review

Country	Competent Authorities	Indicator Typologies	Development Process	Use of indicators by Competent Authorities
Great Britain	Health and Safety Executive (HSE)	<ul style="list-style-type: none"> - Hazard scores of Seveso sites on the basis of intrinsic hazard they pose and their performance in managing accident hazard risk. - Inspection ratings from Seveso sites on the following issues: <ul style="list-style-type: none"> • Competence management systems • On-site emergency planning and mitigation • Off-site emergency planning • Process safety performance indicators • Buncefield response programme • Overfill protection • Secondary/tertiary containment - Injuries, diseases and dangerous occurrences at all UK workplaces are reported to the Health and Safety Executive (Reporting of Injuries, Disease and Dangerous Occurrence Regulations – RIDDOR). - The Seveso sites loss of containment incidents are reported to the European Commission (EC) if they meet the criteria established by the Seveso II Directive. 		<ul style="list-style-type: none"> • COMAH Operational Intelligence System: There are national strategic inspection priorities and performance of sites is scored following inspection so that trends can be recorded and reviewed. • There is also a HSE system in place to periodically review incident causes.

Country	Competent Authorities	Indicator Typologies	Development Process	Use of indicators by Competent Authorities
Italy	Ministry of Environment and regional agencies for environmental protection	<p>Performance indicators of Safety Management System (SMS) are collected by the agency for environmental protection (ARPA) in the Piedmont region.</p> <p>The indicators cover:</p> <ul style="list-style-type: none"> - Organization and personnel - Identification and evaluation of major hazards - Operational control and management of change - Planning for emergencies - Audit review 	Indicators are developed on the basis of the main SMS issues defined in Annex III of the Seveso II Directive.	Performance indicators are used in combination with incident investigations in order to measure the achievement of the objectives set in the major accident prevention policy and to evaluate their adequacy.
France	Ministry of Ecology, Sustainable Development and Energy Direction	<p>Since 1992 all accidents and incidents that adversely affected (or could have affected) human health, public safety, agriculture, nature and environment occurred in France (in case of extreme seriousness also foreign events) are collected in the ARIA database (Analysis, Research and Information on Accidents).</p>	<p>Accidents and incidents are analysed and indicators based on the "Guidance of Developing Safety Performance Indicators" by OECD are apparently extrapolated from the events.</p>	<p>Information on past events are catalogued and shared by means of the ARIA database.</p> <p>The data are continuously updated and analysed in order to develop recommendations. Classified facilities are considered to evaluate risk mitigation measures and remedial actions.</p>

Country	Competent Authorities	Indicator Typologies	Development Process	Use of indicators by Competent Authorities
Germany	The Federal Environment, Labour and Internal Affairs Ministries			<p>Safety performance indicators are not widely used by German authorities. In some cases, where presented by a company, they may be used to understand a company's performance – where the facts match these indicators.</p> <p>There is no assessment of national risk levels and trends for Seveso risk using indicators.</p> <p>Some more comments at the end of this Appendix.</p>
Netherlands	Labour Inspectorate (Ministry of Social Affairs and Employment)	Initiative by the policy unit for safety at work at the Ministry of Social Affairs and Employment to develop process safety performance indicators for Seveso company performance in safety management of major hazards.	Indicators should be based on a list of 30 criteria. For example, an indicator should have a causal link with the risk. In addition, a concrete action on the indicator may be attached, such as improvement interventions. The indicator set should also be sufficient in number and frequency to be able to identify trends.	Monitor the performance of Seveso sites.

Country	Competent Authorities	Indicator Typologies	Development Process	Use of indicators by Competent Authorities
Belgium	Labour inspectorate (Federal Public Service Employment) and Regional environmental inspectorates	<p>Separate elements of plant within an industrial complex are classified by means of the ILO rapid ranking. Three danger categories are used. The category is an indicator of the potential for fire, explosion and acute toxicity. However this does not reflect the overall risk.</p> <p>The labour inspectorate established a limited set of necessary measures (level of protection indicators) as an internal monitoring system.</p>		<p>The ranking technique is used to determine the minimum Seveso inspection frequency.</p> <p>The inspection results are tested to the limited set of necessary measures (level of protection indicators) to monitor a) if these measures are implemented or corrective actions are agreed upon to implement them and b) the inspection plan covers all those items. This is purely <i>internal monitoring</i> system and not meant to measure the “level of risk”.</p>
Sweden	Swedish Civil Contingency Agency (Myndigheten för samhällsskydd och beredskap, MSB)			<p>There is no (known) work in this area within MSB.</p> <p>However, IPS (Intressentföreningen för processsäkerhet) has a report on safety indicators: www.ips.se</p> <p>Also an exam work is written on the topic (rather general): http://www.ips.se/files/pages/27/riskstatu-sbedomning-examensarbete-uu-sara-matson.pdf</p>

Country	Competent Authorities	Indicator Typologies	Development Process	Use of indicators by Competent Authorities
Denmark	Danish Ministry of the Environment (Miljøministeriet, Miljøstyrelsen)			Use of risk indicators is not used in the regulatory work in Denmark. Some enterprises use performance indicators internally. The Danish Ministry of the Environment thinks that authorities should be careful to use risk indicators, as it is difficult to formulate indicators being suitable for comparison of enterprises, and also since the follow up from authorities is difficult if they discover that key figures behind the indicator have changed.
Finland	Finnish Safety and Chemicals Agency (Tukes)	<p>Inspection findings are classified to measure functionality of safety management system. Classify site and its operation. Evaluate (using a grading system):</p> <ul style="list-style-type: none"> - Recognition of the requirement of legislation - Management and personnel commitment to safety - Risk assessment and management of change - Identification of safety requirements (technical, operating, competence) - Emergency preparedness. <p>Also number of accidents (fatalities, injured, leaks).</p>		<p>All input from Tukes was provided in the workshop (see Appendix B).</p> <ul style="list-style-type: none"> - Both leading and lagging indicators are needed. - Measuring functionality of safety, management systems works in practice. - Are discussing a new indicator to assess the technical safety of plants and the safety of surrounding areas.

Some personal comments from Mark Hailwood (Germany) regarding challenges to the use of safety performance and Seveso data to develop a country's risk profile (e-mail; 11 January, 2013):

- a) Based on the premise that indicators are not the end result, but merely a communication tool with a management process to enable systematic decision making to take place:
 - (i) What is to be communicated, too whom?
 - (ii) What can be measured (systematically, reliably, over time)?
 - (iii) Are these measures sufficiently sensitive to any changes to deliver a clear indication?
 - (iv) What is the question that decision-makers are actually trying to answer?
 - (v) Are indicators even a suitable tool for answering this question?
- b) Major Accidents are stochastic events and it is recognized that they are not useful as indicators of risk levels. They are also very low frequency, but potentially high consequence events, so they will provide little reliable input to any indicator level or trend.
- c) Results from safety reports are also not ideal – they describe the hazards and control measures for the risks due to these hazards and describe consequences of major accidents should they occur. On-site and off-site emergency planning is then based on these results.
- d) Internal activities by the operator are highly site specific and not probably well suited to generalizations with an indicator regime.
- e) Land-use planning is an activity which takes place over a time-frame of the order of 20-30 years. The decision making is about balancing risks, benefits and other socio-economic demands. Changes in land-use planning and as a consequence the vulnerability or potential exposure as a result of the implementation of the land-use plan is sporadic and difficult to systematically qualify.
- f) If this “Seveso-risk indicator” or set of indicators is to be shown in comparison to other risk indicators, e.g. air-quality, water-quality, general health, economic risk, etc. then there needs to be clear communication with regard to what is being shown, and what changes in the indicators mean in reality.

Workshop in Tønsberg 30 January 2013

Contents:

- Agenda
- Participants
- SINTEF's presentation

Agenda

Document date
17.01.2013

Your date

1 of 1

Our reference
13/ /LARA

Your reference

To
Participants

File key

Agenda Workshop Risk Indicators for Seveso Plants and Surrounding Areas 30th January in Tønsberg, Norway

- 09:00: Welcome and presentation of participants
- 09:15: DSB – background and information about the Project
- 09:45: Presentation from HSE
- How the agency/ country is working with this issue
 - Experiences and recommendations
 - Future plans
- 10:15: Break
- 10:30: Presentation from TUKES
- How the agency/ country is working with this issue
 - Experiences and recommendations
 - Future plans
- 11:00: Presentation from Petroleum Safety Authority (PSA)
- RNNP – development , experience and recommendations
- 11:30: Lunch
- 12:15: Presentation(s) from industry
- Use of Safety Performance indicators in their industry/ establishment
 - Experiences and recommendations
 - Future plans
- 13:15: SINTEF - Different approaches for development of safety/ risk indicators
- Proposed approach in this project/ work
- 13:45: Break
- 14:00: Discussion
- How different approaches are suitable for monitoring trends in major accident risks (relative to the EU Seveso regulation)
 - How different available information (for example accident statistics, safety reports, inspection results etc.) can be used as indicators
- 16:00: End

PARTICIPANTS WORKSHOP RISK INDICATORS SEVESO ESTABLISHMENTS, Tønsberg 30. JANUARY 2013

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Risk Indicators for Seveso Plants and Surrounding Areas

- Different approaches for development of safety/risk indicators
 - Proposed approach in this project/work

Knut Øien, Per Hokstad & Ranveig K. Tinmannsvik

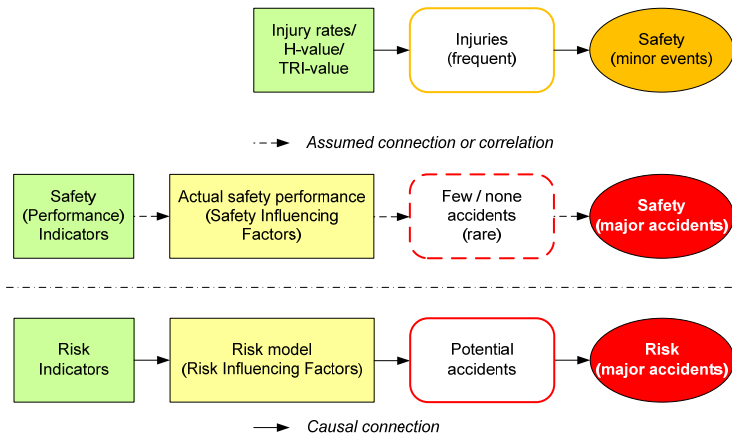
DSB Workshop
Tønsberg, Norway, January 30th, 2013

Overview

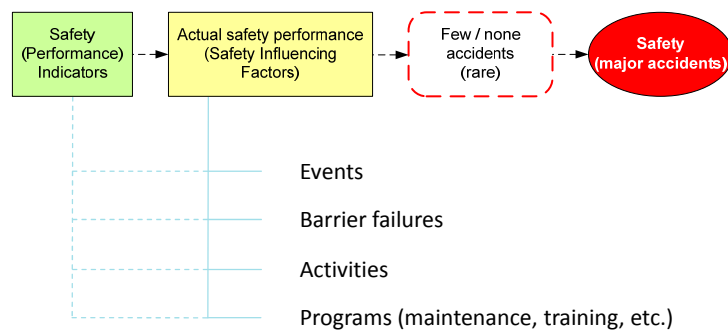
- I. Different approaches for development of safety/risk indicators
- II. Proposed approach in this project/work

A pragmatic and practical view, with just "a taste of theory"

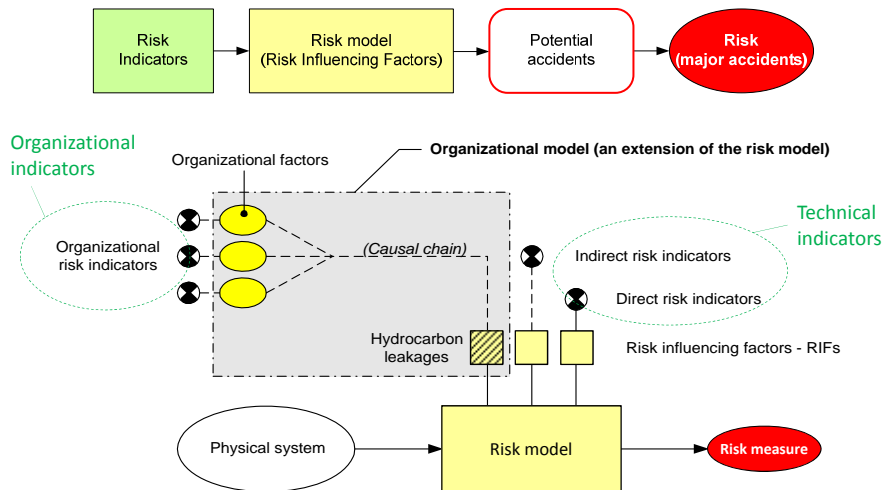
A taste of theory – safety versus risk indicators



Safety performance indicators - classification



Risk indicators - classification



Alternative approaches (and combinations)

Different approaches for the development of indicators may be classified into:

- ✦ Safety performance-based indicators (*assumed to be important to safety*) ✓
 - Event indicators
 - Barrier indicators
 - Activity indicators
 - Programmatic indicators
- ✦ Risk-based indicators (*linked to a risk analysis – can calculate the importance*)
 - Technical indicators
 - Organizational indicators
- ✦ Incident-based indicators
- ✦ Resilience-based indicators
- Dialogue based indicators ✓
- Indicators (simply) based on existing registrations

Selection of approach - criteria

- ✚ How shall the indicators be used? For whom are they going to be a tool?
 - This involves e.g. scope & coverage; i.e.:
 - Entire industry
 - Corporation
 - Company
 - Factory/installation/plant
 - System
- ✚ What are the available foundation/information that the indicators can be based on?
 - Risk analyses; framework of influencing factors; regression or correlation analyses; selected incidents/accidents; minor events/failures; etc.
- ✚ What are the available resources for development of indicators?
 - Time; budget; technical assistance; commitment; organization; etc.

Principles for the suggested main approach

1. Development of indicators in dialogue with the authorities (DSB) and the industry
2. Start with a small number of agreed indicators
3. Test and implement a first set of indicators
4. Gradually develop the set of indicators

Assumptions:

- Authority perspective (entire industry)
- Relatively small resources (time and budget)
- No existing indicators (at DSB)
- Identification and selection based on *assumed* importance, i.e. safety performance indicator approach (if possible use safety reports to evaluate importance)

Question to the workshop participants:

- ✚ Is this a sensible approach or should we adjust it or choose another approach?
(To be discussed ...)

Annual inspections results (nonconformities and observations)

Annual inspections results (nonconformities and observations)

Year		2005		2006		2007		2008		2009		2010		2011			
Number of inspections		52		57		62		60		49		60		60		Sum	
		Non-conf.*	Obs.*	Non-conf.	Obs.	Non-conf.	Obs.	Non-conf.	Obs.	Non-conf.	Obs.	Non-conf.	Obs.	Non-conf.	Obs.	Sum	Total Sum
No.	Topic description																
1	Documentation and management system (incl. expl. prot.)	5	33	20	39	35	43	52	64	25	11	23	38	29	198	255	453
2	Technical deficiencies	2	10	7	17	21	18	19	18	10	15	12	7	21	78	122	200
3	Maintenance and condition monitoring (from 2010)											2	12	6	9	8	29
4	Evaluation and documentation of risk	12	10	16	16	17	18	17	18	5	12	4	13	20	12	91	190
5	Emergency preparedness and training	7	15	8	15	15	14	6	3	5	6	1	5	4	46	62	108
6	HSE procedures, National Seveso Regulation	5	15	4	18	9	5	8	4	5	3	6	12	2	11	39	107
7	Education and training (from 2007; previous topic 5)					6	8	13	4	3	9	2	7	5	8	29	65
8	Treatment of nonconformities (from 2007; previous topic 1)					6	12	4	13	3	8	2	7	5	9	20	69
9	Internal audits and monitoring (from 2007)+ "Other"			4	6	11	3	1	4	1	4	0	1	2	18	20	38
10	Safety reports	3	2	2	0	1	3	2	2	1	2	1	4	1	3	11	27
11	Responsibilities and organisation	0	3	1	2	1	1	1	7	0	4	0	4	1	5	4	30
12	Information to the public	2	5	3	2	4	0	5	6	0	2	0	6	3	3	17	41
13	Warning and reporting (2005)	2	2												2	2	4
SUM TOTAL		38	95	65	115	126	123	128	122	58	76	53	93	116	561	800	1361
* Nonconf. = Nonconformities; Obs. = Observations																	

Comments:

Areas marked with "yellow" colour are topics that were given special attention during inspection, or were obligatory for the year in question.

Review of the annual reports show that total number of nonconformities/observations per year does not completely match with the results found by summing the figures given per topic; therefore the figures have been corrected in the table above.

Safety performance indicators – data provided by the establishments

Safety performance indicators - data provided by the establishments

The establishments were asked to give answers to the following three questions:

1. Does your company use any type of indicators for measuring risk/safety trends?
2. Can you give examples of safety performance indicators you are using (e.g. injury statistics, failure of safety critical barriers revealed during test, maintenance "backlog", and frequency of safety training for operating personnel)?
3. What do you collect/ record of this type of data today?

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 1	<ul style="list-style-type: none"> Near misses (environment, material and humans) Fires/ near fires Injuries (with and without lost time) Environmental spills 	<ul style="list-style-type: none"> Failures to safety equipment 		
No. 2		<ul style="list-style-type: none"> Deviations and dangerous situations: Logging and regular evaluations; reporting every 14 day. Maintenance backlog: Using graphical representation of maintenance and service backlog. 	<ul style="list-style-type: none"> Employees/ contractors with completed safety training: All employees and contract personnel shall have completed web-based safety training. Cycle time (time in stock) for the storage of hazardous waste: Requirements for classification, storage along and retention. Compliance with regulatory requirements: A new compliance data tools, Adept, will provide rapid and clear assessments of the status of compliance with operational and technical requirements. 	<p><u>Additional information:</u></p> <ul style="list-style-type: none"> Checklists for modifications/projects and work permits. A potential for improvement: To collect and structure data from paper to "digital" trend analyses.

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 3	<ul style="list-style-type: none"> Lost Time Accident (LTA) frequency rate (number of accidents per 1 mill. working hours) See comments: 1) and 2). Severity Rate (LTA) Medical Injury Frequency Rate Total Injury Frequency Rate Adverse events: Leaks, things that fail, potentially dangerous situations that arise, etc. 	<ul style="list-style-type: none"> Deviations: Deviations identified during inspections or reported via the common electronic failure/ deviation log. Required maintenance: Defective equipment, lack of equipment, etc. Reported by the common electronic failure/ deviation log. 		<p>1) A challenge to define the events correctly so that the numbers are comparable to figures from sister factories in the U.S. and the global figures on group level.</p> <p>2) Use "Safety Tracker" to communicate safety to all employees: Monthly overviews (red, yellow, green).</p> <p><u>Additional information:</u> In a process of figuring out how to present and use information from adverse events.</p>
No. 4	<ul style="list-style-type: none"> Near misses Injuries (with and without lost time) On-line monitoring and logging of discharges 	<ul style="list-style-type: none"> Serious deviations: Trending of frequency/number of deviations; comparing with the previous period (month/year), causal relationships. 		<p><u>Additional information:</u></p> <ul style="list-style-type: none"> - Performing risk and vulnerability analyses systematically. - Periodic visual inspections with personal responsibility and signing. - Maintenance Program and criticality analyses of all equipment. - Training Program in accordance with annual HSE&Q plans and Introduction Program.
No. 5	<ul style="list-style-type: none"> Adverse events 			<p><u>Additional information:</u></p> <ul style="list-style-type: none"> - Systematic logging at the plant once a week; results documented in a specific form. - Operational failures/defects listed in a separate form; repairing as soon as possible. - Annual inspection by external company, as well as by the Notified Body. All alarms etc. are tested. - Repetition course for operators on guard ("driftsvakter") every other year. First Aid Courses conducted annually.

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 6	<ul style="list-style-type: none"> Incidents/near misses 			<p><u>Additional information:</u></p> <ul style="list-style-type: none"> Adequate overview (by regular inspections) of safety critical equipment; monthly checks of valves, pipes, pumps and flanges at the storage facility. Deviation reports as a documentation of incidents in relation to HSE and also with regards to problems that may arise during normal operation.
No. 7	<ul style="list-style-type: none"> Injury statistics (corporate -/group level) 	<ul style="list-style-type: none"> Deviation in inspection procedures, failure of barriers etc.: Factors related to process safety and PSI (Process Safety Indicators) are addressed separately. The system provides overview and trends and may also include deviations from the inspection procedures, failure of barriers. 	<ul style="list-style-type: none"> Frequency of HSE training and other education/training: The company has an overview of the qualifications and competences of each person (in SAP; an electronic database). They also offer online safety courses with a written test, where the results are stored. 	<p><u>Additional information:</u></p> <p>Regarding changes in risk:</p> <ul style="list-style-type: none"> Analysing the changes in risks in terms of consequence or probability changes. An important factor is the impact of control measures and ensuring they are maintained. The company applies a database to the risk register where risks are monitored locally on the site, but also on a group basis. Changes in the system are captured and must be accounted for. New risks are added and irrelevant risks are removed. The system provides reports and an overview of risks and control measures. Preventive maintenance is monitored through SAP. Inspections and tests can be traced and give an overview of follow-up actions in specific areas. The company collects other safety information, including access control, inspections, external and internal audits, etc.

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 8	<p>Personal safety:</p> <ul style="list-style-type: none"> Lost Time Injury Frequency Rate – LTI Total Recordable Injuries – TRI Near misses Dangerous conditions/dangerous behaviour: <p>Registration and trend analyses</p> <p>Environment:</p> <ul style="list-style-type: none"> Violation of the internal discharge limits and concessions (including measures to prevent recurrence) Trends in discharges <p>Process safety:</p> <ul style="list-style-type: none"> Major spills 	<p>Process Safety Indicators, PSIs:</p> <ul style="list-style-type: none"> Number of bypasses Priority 1 repairs, in % of total Number of shutdowns Number of safety valve liftings % overdue of open TOPS deviations % of modifications without risk assessment % of WP and checklists not correct <p>TOPS = Technical and Operational Standard WP = Work Permit</p>	<ul style="list-style-type: none"> Competence matrix for employees Safety training for contractors/suppliers Complaints from neighbours 	<p><u>Additional information:</u></p> <p>Personal safety:</p> <ul style="list-style-type: none"> Risk assessments of operations (use of chemicals, noise, ergonomics, psychosocial). Periodic inspection of working environment (rolling each 3rd year). <p>Environment:</p> <ul style="list-style-type: none"> Coarse Analyses (a minimum of two barriers are required) Risk assessments <p>Process safety:</p> <ul style="list-style-type: none"> Coarse Analyses; quantitative risk assessment (individual risk and societal risk) <p><u>Other data recorded:</u></p> <ul style="list-style-type: none"> Risk-based inspection setup (RBMII) HSE monitoring of suppliers <p>RBMI = Reliability Based Mechanical Integrity</p>

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 9	<ul style="list-style-type: none"> Serious Incident Frequency – SIF: The number of serious HSE events (including dangerous conditions and near misses, but excluding cases of malpractice), categorized with potential severity levels 1 and 2 per million working hours. Total Recordable Injuries Frequency – TRIF: Number of fatalities, lost time injuries, injuries with alternative employment and medical treatment per million working hours. Oil and gas leaks and discharges: Number of oil and gas leaks, and discharges categorized by potential severity levels 1 and 2. Frequency of falling objects: Number of HSE incidents of falling objects or potentially falling objects (excl. consequences as lost production, property damage and other costs), categorized with potential severity level 1, 2 and 3 per million working hours. 	<ul style="list-style-type: none"> Environmental standard: % achievement of goals of defined environmental indicators. Maintenance backlog – safety critical equipment: The ability to conduct maintenance on safety critical equipment in accordance with deadline, based on backlog of preventive and corrective maintenance. Technical Integrity – TIMP: State of technical integrity by the use of TIMP (Technical Integrity Management Portal). Technical Condition Safety ("Teknisk Tilstand Sikkerhet") – TTS: TTS implies a proactive, independent and systematic assessment of the state of technical safety with a focus on safety barriers that affect the risk of major accidents. Operational Condition Safety ("Operasjonell Tilstand Sikkerhet") - OTS (under implementation): OTS implies a systematic, comprehensive and independent survey and description of the state of operational safety barriers of great importance for the risk of major accidents. 		

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 10	<ul style="list-style-type: none"> Recordable injuries (incl. process safety) Lost Time Injury Frequency Rate – LTI Incidents with potential injuries Number of near misses Frequency of near misses Sick leave Accidental release to treatment plant Fire/smoke 	<p><u>Future plans:</u></p> <ul style="list-style-type: none"> Increase SIL-level (Safety Integrity Level); systematic process system review. Bypass status (weekly audits): <ul style="list-style-type: none"> Control system Fire detection system MOC like working permits Operator mind set (interviews) 	<ul style="list-style-type: none"> Incident reporting closing rate (target: > 90 %). HSE training (operating personnel). Safety walks every month (participation rate > 60 %). Safety meetings (target: 4 – 12 per year per plant; site target depending of the size of the site). 	<p><u>Additional information:</u></p> <ul style="list-style-type: none"> Indicators assessed against a target/ a threshold value.
No. 11	<ul style="list-style-type: none"> High Potential – HIPO: Number of incidents involving potential for, or actual consequences and a recurrence frequency resulting in "red" in the risk matrix. Loss of Containment – LOC: Discharges of hazardous material that exceeds a specified threshold value. 	<ul style="list-style-type: none"> T- value (technical integrity): <ul style="list-style-type: none"> <i>Barrier indicator:</i> Number of errors per number of executed tests <i>Inspection indicator:</i> Number of findings per number of inspections on safety critical systems <i>Override indicator:</i> Number of actual overrides per number of possible, critical overrides Engineering Compliance: % overdue of actions/ measures after inspections. Safety Critical alarms initiated/systems activated. 		

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 12	<ul style="list-style-type: none"> • Lost time injuries • Injuries without lost time • First aid injuries • Sick leave 	<p><u>Process Safety Indicators – PSI:</u></p> <ul style="list-style-type: none"> • Gas alarms: Alarm from the detectors and measures to eliminate cause (may be a little spillage by the detector, a droplet, improper handling, etc.) • Fire alarms: Incl. sprinkler, faulty alarms in the system, etc. • Overpressure protection/rupture disc: Triggered by pressure or faulty disc (new from 2013). <p><u>Faulty safety barriers:</u></p> <ul style="list-style-type: none"> • Registry of overpressure protection/-rupture disc failures; measures to modify and adjust failures. • Maintenance history of equipment such as pumps, compressors, ventilation systems, gas detectors, etc. 		<p><u>Additional information:</u></p> <ul style="list-style-type: none"> - Initiated new training program for 2013 with process simulation and alarm training. - Safety training on working procedures, chemicals, safe job analysis, etc.; regular use of electronic training program.

Establishment	Outcome/event based indicators ("lagging")	Technical/operational indicators ("leading")	Organizational indicators/ SMS – Safety Management System ("leading")	Comments
No. 13	<ul style="list-style-type: none"> Personal injuries (frequency) Critical events (frequency) Gas leaks (number) Unintentional oil/chemical release 	<ul style="list-style-type: none"> Barrier Integrity indicator (Barrier KPI): The indicator provides an overview of the condition and functionality of safety critical barriers. <p>The following items are included:</p> <ol style="list-style-type: none"> <i>Aggregated Management Elements:</i> <ul style="list-style-type: none"> PM (Preventive Maintenance) <ul style="list-style-type: none"> backlog on safety critical equipment CM (Corrective Maintenance) <ul style="list-style-type: none"> backlog on safety critical equipment Critical audit findings Overdue action son critical audit findings Override indicator Open notifications related to safety critical failure modes <i>Aggregated Proactive Elements:</i> <ul style="list-style-type: none"> Inspection findings PSV (Pressure Safety Valve) HIPPS (High-Integrity Pressure Protection System) <i>Aggregated Reactive Elements:</i> <ul style="list-style-type: none"> Automatic gas detection HVAC (Heating, Ventilation and Air Condition) ESD (Emergency Shut Down) – Valves ESD – Pushbutton Blowdown Fire detection Fire monitors Fire water pumps PA (Public Address) system Emergency power generator UPS (Uninterruptible Power Supply capacity Emergency lighting Safety critical PSD (Process Shut Down) valves 	<ul style="list-style-type: none"> Implementing HSE&Q program according to plan (%). 	<p><u>Additional information:</u></p> <ul style="list-style-type: none"> Barrier KPI was implemented and tested for all company facilities in 2010. Barriers at all gas terminals, processing plants, pipelines and riser platforms are monitored. A selection of reactive and proactive barriers and management elements are reported to the company management on a monthly basis and their state are aggregated from a system/facility level to a corporate level.

The OECD guidance on developing safety performance indicators

In similarity with the method developed by HSE and CIA (2006), the Organisation for Economic Cooperation and Development (OECD, 2008) base their method on the use of a set of proactive and reactive indicators (*activity* and *outcome* indicators). The method is also founded on the safety management system and accident scenarios. Activity indicators measure to what extent the company carries out the activities that they believe are necessary to reduce risk (such as adequate monitoring of procedures and practices), while outcome indicators measure whether the company achieves the desired results.

The method comprises the following seven steps:

1. *Establish project team.*

2. *Identify key risk areas to be included in the indicator set.* The focus is primarily on what should be measured, rather than what can be measured. Risks areas can be identified for example by reviewing hazards and risks, or consider the consequences of deviation from existing procedures and practices.

3. *Define outcome indicators and measurement scale.* Outcome and activity indicators should be established in parallel for a risk area at a time. This is recommended rather than defining all outcome indicators first, and then defining all activity indicators. The indicators should be defined by describing what is to be measured, and a measurement scale that results will be measured against. The objective is that the indicators should be able to give a clear message to those responsible for implementing safety improving measures.

4. *Define activity indicators and measurement scale.*
See step 3.

5. *Collect data and report results.* This includes the specification of data sources, as well as roles and responsibilities in the collection, processing and reporting, and the frequency of reporting. If the indicators are linked to the acceptance criteria, the acceptance criteria have to be defined. The reporting shall be made as simple as possible, and it is intended to highlight trends and deviations from the acceptance criteria. The reporting should also show the link between outcome and activity indicators.

6. *Implement measures.*

7. *Evaluate and improve indicators.* The set of indicators will be reviewed and evaluated regularly to ensure that the indicators reflect the major risk areas and that the indicators are adequately defined. If an outcome indicator and an activity indicator within the same risk area show conflicting results, it can be an indication that one or both of the indicators are not sufficiently defined.

Important aspects for the design and operation of a safety performance indicator system (RIVM Report 620089001/2012, The Netherlands)

As a result of the current review 20 aspects are considered important, but not necessarily complete, for the design and operation of a safety performance indicator system:

1. A link (usually causal) to the major hazard (process) risks, with appropriate coverage and priorities in the (safety) management system;
2. Sufficient in number and frequency to be able to identify trends (e.g. quarterly, yearly, three-yearly), including any 'Rasmussen drift' effects towards boundaries of safe operation to allow appropriate recovery in time;
3. Tailor-made for the company/site;
4. Metrics distinguish between good and bad in the population distribution (this also facilitates benchmarking);
5. Consideration of published guidance (HSE, CCPS, OECD, API, Deltalinqs, CEFIC etc.);
6. Quantitative measureable indicators associated with defined objectives;
7. Precursor (prior to loss/harm) indicators of sufficient scope and sensitivity to give sufficient and timely 'warning' of deviations from safe standards of design and operation;
8. Precursor indicators on management system inputs to major hazard risk control processes and indicators on related outputs of these processes;
9. Evaluation of management inputs, outputs and incidents for relationships, interactions, causes and major hazard risk potential;
10. Specification of indicator tolerances with justification in safe boundaries of operation and associated with action levels;
11. Specification of indicator targets, especially in relation to the objectives of the major accident prevention policy;
12. A selection of KPIs for reporting to the top management;
13. Indicators that are actionable, in that there is a connection between the indicator and the actions which should affect it;
14. A reporting culture involving the whole workforce who have responsibilities in the control of major hazards;
15. Workforce involvement in indicator development and reporting programmes;
16. A leadership which maintains the reporting culture and which ensures actions are carried out in time;

17. A leadership which positively influences safety culture through interactions with the workforce, safety improvement (programmes), and measuring the effect on safety attitudes and awareness;
18. Consideration given to using metrics that could be sensitive to changes in the external system climate (such as economic pressures, takeovers, new knowledge) and their impact on safety at the plant;
19. Indicator review and improvement at least on a yearly basis;
20. Use of indicators also by external bodies about their own performance, particularly emergency response organisations. This point has not really been elaborated in the review, but it suffices to say that if they are part of the socio-technical safety system affecting plant then perhaps emergency responders should also be part of the measurement system.

From the review, a further ten points are considered specifically for the regulator:

21. Leading KPIs should give signals for concern about future safety.
22. Lagging KPIs should show past performance.
23. KPIs should identify degradation in safety performance as early as possible.
24. KPIs should be designed according to the way they are to be used by the regulator.
25. Consideration should be given as to whether indicators can be used standalone.
26. Aligning action levels with KPI measurement should be possible.
27. KPIs should be clearly defined and unambiguous to ensure accurate communications with stakeholders.
28. KPIs should not be capable of being manipulated.
29. Learning from the use of indicators may require changes in the set of KPIs used or associated action levels over time.
30. Standardisation, e.g. based on number of hours worked, could facilitate comparisons between companies.

Sample fact sheet – safety performance indicators

Indicator No. 5	Maintenance backlog on safety critical equipment
Definition Number of hours preventive maintenance (PM) on safety critical equipment that is not done within the stipulated completion date	
Description Maintenance backlog (PM) on safety critical equipment; number of hours lag on safety critical equipment	
Data sources Maintenance program	Responsible Maintenance manager
Registration/ calculation Number of hours lag in PM on safety critical equipment at the end of each month	
Acceptance criteria For this indicator no acceptance criteria is currently in use	
Evaluation/ justification The backlog in maintenance provides early warning of potential increase in the risk of major accidents. This indicator is one of several maintenance indicators introduced by the Petroleum Safety Authority Norway in the project RNNP (<i>Trends in risk level</i>).	
Comments/ references The indicator is developed based on input from the Seveso establishments and comments/ suggestions from SINTEF. The indicator is adapted to requirements of internal reporting and reporting to the authorities.	
Revision Last revision: <i>date</i>	

Abbreviations

ARIA	Analysis, Research and Information on Accidents (France)
ARPA	Agency for Environmental Protection (Italy)
BARPI	Bureau for Analysis of Risks and Industrial Pollution (France)
BRZO	Besluit Risico's Zware Ongevallen (The Netherlands: Abbreviation for Major Accident Regulation)
CIA	Chemical Industries Association
CM	Corrective Maintenance
COMAH	Control of Major Accident Hazards
CSB	Chemical Safety Board (U.S.)
DSB	Directorate for Civil Protection (Norway)
DSHA	Defined Situations of Hazards and Accidents
EC	European Commission
EEA	European Economic Area
ESD	Emergency Shut Down
ETPIS	European Technology Platform for Industrial Safety
EU	European Union
EU-Vri	European Virtual Risk Institute
HIPO	High Potential
HIPPS	High-Integrity Pressure Protection System
HSE	Health and Safety Executive (Great Britain)
HSE	Health, Safety and Environment
HSE&Q	Health, Safety, Environment & Quality
HVAC	Heating, Ventilation and Air Conditioning
ILO	International Labour Organization
iNTeg-Risk	Early Recognition, Monitoring and Integrated Management of Emerging, New Technology Related Risks
IPS	Intressentföreningen för processsäkerhet (An association for process safety in Sweden)
KLIF	Climate and Pollution Agency (Norway)
KPI	Key Performance Indicator
LOC	Loss of Containment
LTA	Lost Time Accidents
LTI	Lost Time Injury
MSB	Swedish Civil Contingencies Agency (Sweden)
OECD	Organisation for Economic Cooperation and Development
ORIM	Organizational Risk Influence Model
OTS	Operational Condition Safety
PA	Public Address
PM	Preventive Maintenance
PSA	Petroleum Safety Authority Norway
PSD	Process Shut Down
PSI	Process Safety Indicators
PSV	Pressure Safety Valve
RBMI	Reliability Based Mechanical Integrity
REWI	Resilience based Early Warning Indicators
RIDDOR	Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (Great Britain)
RIVM	National Institute for Public Health and the Environment (The Netherlands)
RNNP	Trends in Risk Level in Petroleum Industry (Norway)

SamBas	Societal Safety Database (Norway)
SAP	Abbreviation for an administrative management system
SEPA	Scottish Environment Protection Agency
SIF	Serious Injury Frequency
SIL	Safety Integrity Level
SMS	Safety Management System
TIMP	Technical Integrity Management Portal
TOPS	Technical and Operational Standard
TRI	Total Recordable Injuries
TRIF	Total Recordable Injuries Frequency
TTS	Technical Condition Safety
TUKES	Finnish Safety and Chemicals Agency
UPS	Uninterruptible Power Supply
WP	Work Permit



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