Statistics and analysis of HSE incidents and data

Working Together for Safety Recommendation 035E/2025

Prepared by the Working Together for Safety Working Group: **August 2020** **Reviewed and continued without changes in March 2025**	Revision: **Rev 01**	Working Together for Safety Project Manager: Hugo Halvorsen Hugo Halvorsen (sign. on file)
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Contents

1. Introduction

Section 16 of the Norwegian Ocean Industry Authority's Management Regulations sets general requirements regarding analyses. The responsible party shall ensure that analyses are carried out which provide the necessary basis for making decisions to safeguard health, safety and the environment.

Section 19 of the Management Regulations also states that the responsible party shall ensure that data of significance to health, safety and the environment is collected, processed and used for carrying out and following up analyses during various phases of the organisation's activities and in the implementation of remedial and preventive measures.

2. Purpose

The purpose of this recommendation is to:

- Create a common understanding of the terminology and work processes relating to statistics, trend evaluation and the analysis of HSE incidents/data.
- Provide an introduction to methods that can be used in the evaluation of trends and analysis.
- Indicate the usefulness, limitations and learning that can be expected from statistics, trend evaluation and analysis.

The recommendation examines the analysis and statistics of several incidents/large datasets. For the investigation of individual incidents, refer to Recommendation 029E "Best Practice for Investigation and Inquiry into HSE Incidents". For more info on learning, reference is made to SfS Recommendation 043E "Learning from incidents". SfS recommendation 037E "Reporting" could also be relevant.

3. Changes from the previous version

References to other SfS recommendations regarding undesired events were included in 2020. Other than that there are only minor changes in the form of improved language and clarity. In 2025, the recommendation was reviewed and continued without any other changes than names and reference to the HOP principles.

4. Terminology and definitions

HSE incident
A hazard and/or accident situation that has occurred and which could have or has resulted in injury, pollution or the loss of economic assets.

HSE data
Data which is of significance for health, safety and the environment. This can include data from data sources other than HSE databases, such as operational data, maintenance data and data from surveys. These kinds of data can be used proactively in order to avoid incidents.

Statistics, trend evaluation and analysis
Statistics and the analysis of HSE incidents/data can be divided into three different levels as described below.

A. **Statistics**
Data collected over a specified period of time. Extraction of data from various source systems, followed by visual presentation.

B. **Trend evaluation**
Change of data between specified time periods. Is normally based on the extraction of data from databases. Visual presentation with comments on and analysis of the results. Often with recommendations for improvements. Provides an understanding of changes and trends.

C. **Analysis**
Is a systematic investigation/review of HSE incidents/data, in order to better understand and form a picture of e.g. the course of events leading up to an incident, causal relationships, barrier failures, consequences, potential losses and areas for improvement. The investigation is carried out in order to understand causes, barriers and/or connections between human, technological and organisational factors, and thereby provide the best possible decision-making basis and support in decision-making processes.

Ref. Appendix 1 for a short summary of statistics, trend evaluation and analysis.

5. Criteria for the initiation of trend evaluation and analysis

It is advantageous to establish criteria in order to determine whether trend evaluation and/or analysis shall be carried out. Here are some examples:

- There is uncertainty regarding a change in the HSE level, e.g. a performance indicator moves in an undesired direction
- The organisation needs to map trends, e.g. within a defined area, within a selection of types of hazard and accident situations, or within a certain type of activity
- Prior to critical operations
- Suggestions for HSE in design and development projects
- Need to assess risk levels, basis for risk and emergency preparedness analyses
- Need a decision-making basis in order to prioritise measures
- Need to evaluate the employees’ exposure to working environment factors, e.g. noise or chemicals, including groups exposed to risk

6. Processes for statistics, trend evaluation and analysis

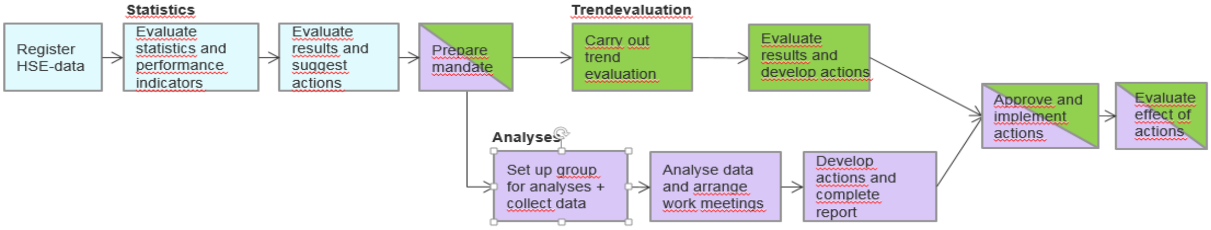

Figure 1: Flow chart – statistics, trend evaluation and analysis

Statistics

Data will be registered and visualised using statistics, graphical presentations and performance indicators. The data and performance indicators should be reviewed and evaluated in order to determine whether there are types of incidents, work processes, activities, systems, equipment, causes of incidents, etc. that require special attention. Based on the HSE results, as well as on-going and planned operations or projects, continuous assessments of whether there is a need for a trend evaluation and/or analysis should be carried out.

Trend evaluation

A brief work description/mandate should be prepared, with details of the background and purpose of the trend evaluation/analysis, a description of the problem/hypothesis, the data that shall be included, the selected method, what the delivery should contain, and what one wishes to achieve.

Trend evaluations can be useful for assessing the development/change in various types of defined hazard and accident situations, and for showing the change over time in, for example, causal relationships, barriers, the severity of incidents and potential.
Trend evaluations can also help to provide answers to questions such as:

- Has the HSE work provided improved results over time, or are we still making the same mistakes?
- Has the introduction of a new system/piece of equipment, new work practice or change in the organisation resulted in changes in trends?
- What has been the effect of implemented measures?
- Why does one location have better results than another?

The organisation should carry out trend evaluations on a regular basis. Trend evaluations can identify hazards/risks that are not reflected in statistics and/or performance indicators and can provide an indication of areas which should be analysed in greater depth.

Interviews will not normally be held as part of a trend evaluation.

Analysis

When carrying out analyses, personnel with competence within analysis processes and knowledge of methods, interview techniques and surveys should be involved.

The analysis should be carried out in accordance with the mandate or work description/procedure. When collecting data, databases and written sources such as statistics, trend evaluations, analyses and investigation reports (internal and external) can be used.

Factors that can be decisive for the choice of analytical method include:

- Qualitative or quantitative analysis?
- The number of cases to be analysed (e.g. 2-5 cases or all cases within a given time period)
- The type of cases that shall be analysed (e.g. the most serious cases or all incidents with the same consequences)
- Which system, area or activity shall be covered by the analysis?
- What does one wish to achieve with the analysis?

Some methods that can be used individually or in combination with each other include:

- Man, Technology, Organisation (MTO)
- Human Factors (HF)
- The loss causation model

Some ways of approaching the analysis work include using methods such as analysis of the events leading up to the incident, causal analysis, barrier analysis, organisational analysis, mitigation analysis, etc. Analyses which use several methods in combination often provide the best results. The HOP principles should be emphasized in analyses and assessments of measures, see Appendix F.

Analysis of the events leading up to the incident:
STEP (Sequentially Timed Events Plotting) is the sequential plotting (description) of sub-incidents by time. The method involves plotting the incidents for each actor (person, procedure, equipment, etc.) along a time axis. The final product is a complete and detailed overview of the sub-incidents prior to and after the incident. Each actor's movements and conduct are also shown.

Causal analysis:
The aim of causal analysis is to identify the causes of problems or incidents. Immediate and underlying causes and causes relating to management and control. Methods that can be used include for example the loss causation model, MTO, TRIPOD, Human Factors Analysis Tool (HFAT), AcciMap in order to analyse human behaviour and Fault Tree Analysis to analyse technical causes.

Analysis of barriers:
Technical barriers can be analysed in combination with causes, equipment and systems, as well as data from verification activities and maintenance databases, e.g. registered nonconformity of critical barriers and failures in connection with the testing of equipment.

Organisational analysis:
Organisational analysis aims to generate an understanding of the structure and culture of the organisation. Suggested methods for organisational analyses include affinity diagrams, fishbone diagrams, the Human Factors (HF) approach and AcciMap.

Mitigation analysis:
The objective of mitigation analysis is to evaluate the quality in recommendations following incidents, including recommendations in investigation reports. It is also possible to assess the status of the implementation of the measures.

Ensure quality in the delivery:
Workshops and/or brainstorming can also be used in order to ensure good quality prior to a consultative round regarding the analysis. The working group must ensure that the analysis work is in accordance with the mandate/work description.

It can be useful for the analysis group to arrange a meeting/seminar in order to present the preliminary results and proposed measures in order to obtain feedback and any further information. Employee groups that are particularly affected by the proposed measures should be represented.

The principal shall review and evaluate the proposed measures with a view to registration and further follow-up. If the proposed measures are not taken into consideration or implemented, this should be documented. The organisation should have routines for the assessment of the effect of the implemented measures.

7. Report

The results of an analysis should normally be documented in a report. It can be useful to create a short version which can be used to share the most important learning points, but the main report must include all aspects of the analysis. This gives others who wish to compare the findings with other reports data and enough insight to make comparisons in an effective manner.

As a minimum, the analysis report should include:

- A summary of the main points, discussion of results including the significance of the results
- The group’s members, mandate (if relevant) and signatures
- Methods, limitations, uncertainty, assumptions and conditions

The report may also include:

- Background to and purpose of the analysis
- Causal and barrier and analyses including relevant diagrams and/or models
- Potential losses, possible benefits and risks
- Transfer of experience and learning
- Recommendations, with cost/benefit analysis if necessary

Language that is clear and easy to understand should be used in the report and presentation material.

If transfer of experience and learning isn’t part of the main report the results from the analyses must be included when decision on actions and improvement measures are taken. Se also SfS recommendation 043E “Learning from incidents” for recommended practice in this area.

8. Usefulness and limitations

As previously mentioned, analysis results and statistics satisfy statutory requirements and provide relevant information for owners, partners and other stakeholders. They also provide a basis for making decisions and identifying areas for improvement within:

- Design
- Modifications, technical improvements
- Governing documents – improved procedures
- Organisational changes – roles and areas of responsibility
- Work processes
- HSE culture

In order to ensure that the desired utility value is achieved, one must be aware of limitations and prerequisites. These may include, for example:

- Changes in definitions, different criteria
- Changes in prerequisites and conditions that are not included in the analysis
- Insufficient understanding of the source data and relevant problems
- History does not always provide a basis for prediction
- Generalisation of data – conclusions and results cannot always be used by others
- Inherent limitations of the selected method + limitations in the competence of those who have undertaken the analysis (follow template and lack ability to see other conditions)

The data used in the work should be quality assured, preferably quantitatively, and must cover the area being studied. Care must be taken not to use a small sample of data (such as the number of injuries) to draw general conclusions. Using different methods and several sources of data provides a better decision-making basis. The figure below shows how several methods and sources of data are used in analyses to assess the level of risk in Norwegian petroleum activities (RNNP).

Correspondingly, the companies should use the results from statistics and analyses as part of the basis for making decisions regarding risk level reduction in their activities.

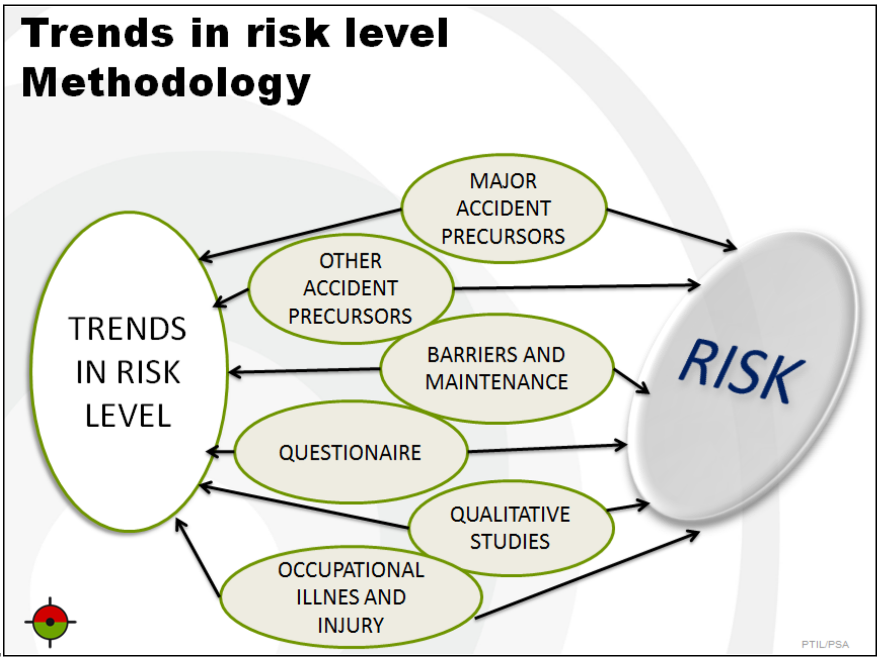

Figure 2: Risk level trends – Overview and methodology

Appendix A: Statistics, trend evaluation and analysis

The purpose of this table is to clarify the differences between statistics, trend evaluation and the analysis of HSE incidents/data.

<table>
<tr><th></th><th>Description</th><th>Method</th><th>Mandate (if relevant)</th><th>Delivery</th></tr>
<tr><td>Statistics</td><td>Automatic and/or manual extraction of HSE incident/data and visual presentation of data.</td><td>Automatic transfer of data from databases and/or manual extraction of data.</td><td>No mandate. Routine work based on reporting requirements and the organisation's need for control and management.</td><td>Automatic presentation of data and/or presentation package.</td></tr>
<tr><td>Trend evaluation</td><td>Systematic review of HSE data and the long-term trends in HSE incidents.</td><td>Analysis of trends based on automatic/manual searches in databases.</td><td>Statistics and other factors/conditions may provide a basis for carrying out a trend evaluation. The scope, prerequisites and limitations will be defined in the mandate.</td><td>Presentation package. The product may be findings and recommendations for improvements and/or suggestions for further analysis.</td></tr>
<tr><td rowspan="2">Analysis</td><td colspan="4">The analysis may start with a brief review of the statistics and an evaluation of trends. In addition to statistics and trend evaluation, the analysis includes a more thorough review of various categories based on problem descriptions, e.g. work processes, activities, equipment, causes, barriers and measures. Correlations between these may be relevant. Analyses often include the perusal of investigation reports, brainstorming, workshops, interviews, surveys and the involvement of specialist personnel.</td></tr>
<tr><td>May be an analysis of all incidents/data within a defined time period or a smaller sample of HSE incidents, e.g. within a particular type of hazard and/or accident situation or a selection of the most serious incidents.
Analyses may also cover specific systems or activities, such as exploratory drilling in the Barents Sea.</td><td>Combined search and/or correlations of data relating to HSE incidents based on a description of a problem/hypothesis. Also includes data from databases and/or external reports.</td><td>Mandate will be established through collaboration between the principal and analysis manager. This involves defining the scope, limitations, method, and composition of the analysis group/reference group and steering committee, and identifying competence needs from relevant areas.</td><td>Analysis report. Presentation package. The measures are defined in accordance with "SMART" and are based on causes and conclusions, see attachment.</td></tr>
</table>

Table A1: Statistics, trend evaluation and analysis

Appendix B: Some models and methods

This appendix briefly describes some examples of models and methods that can be used in the execution of analyses of HSE incidents and data. It is recommended that several methods are used in an analysis.

a. Energy and barrier perspective

The energy and barrier perspective focuses on the transfer of uncontrolled energy to a vulnerable target (Rossnes et. al, 2004). Accidents occur when this energy influences objects in the absence of barriers between the source of energy and receiving object (Haddon, 1970, 1980).

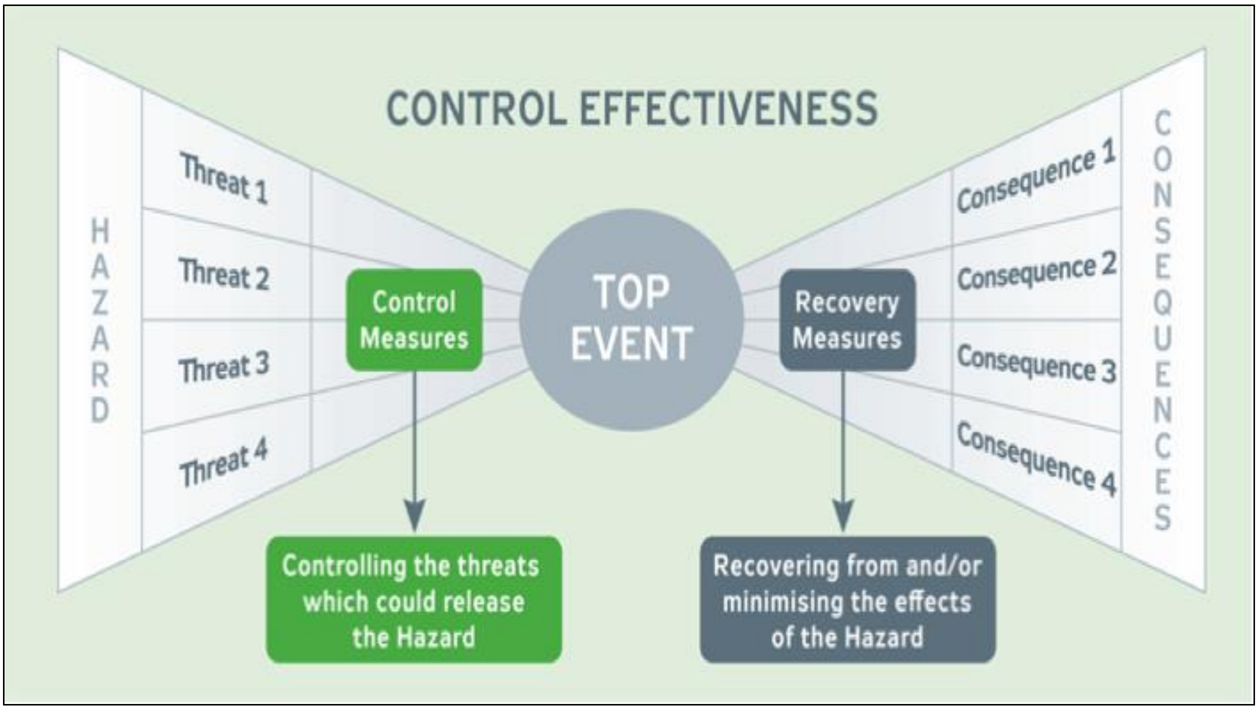

Figure B1: "The bow-tie model"

Barriers can be in place prior to an incident (in order to reduce the probability) but we also use the term "barriers" to describe elements that provide reduced consequences following an incident. This is often illustrated in the so-called "Bow-tie model" (Aven, 2008). According to Haddon (1970, 1980), examples of measures that can be implemented in order to establish barriers that can control the energy in this perspective include:

- Reduce the accumulation and amount of energy
- Prevent the uncontrolled release of the energy
- Spread or divert the release of the energy
- Separate the release of energy and the elements that are affected by time
- Develop and adapt the objects' ability to withstand the energy

In our experience, this perspective provides an effective and useful approach to the analysis of HSE incidents. The perspective provides a methodical approach, but mostly focuses on human and technical barriers. The organisational barriers can be easily overlooked if one does not continuously ask *why* the human and technical barriers failed.

This perspective is also suitable for preventive work in that it enables focus to be maintained on the handling of the energies as a way to avoid accidents. In addition, by looking at the quality of the barriers and their robustness against incidents, it is possible to carry out so-called QRAs (Quantitative Risk Analyses), which provide a good insight into the overall risk picture for a given area.

b. Sequentially Timed Events plotting (STEP)

STEP (Sequentially Timed Events Plotting) is an investigation methodology which structures the description of a chronological and multi-linear course of events, i.e. highlights where several actors' individual incidents occur simultaneously (Sklet, 2002). All actors (people or objects) that actively contribute to bringing about the incident are included, and the diagram shall describe their actions in parallel and chronologically. Locations where the course of events could have been broken/stopped or where practice differs from procedures/best practice are marked in the diagram as barrier breaches/safety problems. Events that are in a cause-effect relationship are linked together using arrows. As with MTO, STEP provides a starting point for the further analysis of underlying causes.

Advantages of STEP include:

- The course of events is tested with regard to necessity (does the incident belong here?), adequacy (are any incidents missing?), continuity (is it possible to follow the actor's actions throughout the chain or are there "holes"?) and timing (are the incidents in the correct order?).
- Provides a good overview of the time axis and involved actors.
- Standardises the presentation of the course of events and identifies concrete problems.
- The method is verifiable.

The STEP method is also associated with some disadvantages:

- Not suitable for analysis where the course of events only consists of few actors/few individual incidents.
- Less "visible" elements, e.g. relating to the safety culture, etc., are difficult to include.
- No clear rules regarding when to start and stop the analysis.

c. Man, Technology and Organisation (MTO)

MTO (Bento, 2001) is a comprehensive analysis method which focuses on factors and causes relating to human, technical and organisational conditions. A key component in systematic thinking is to recognise that problems do not exist in isolation. An MTO analysis may focus on incidents and accidents that have already taken place, but is also a good way of working actively to anticipate problems, which can then be handled before accidents occur.

The MTO diagram describes the course of events in chronological order, while simultaneously clarifying which nonconformities have taken place (these may be nonconformities relating to procedures, best practice, maintenance routines, statutory requirements, etc.) and which barriers have been breached and/or functioned. MTO is a methodology that is used extensively within the petroleum industry and has a number of advantages:

- Suitable method when causal relationships are complex (human, technical and organisational factors are involved).
- Possible to classify causes (cause codes/checklists exist).
- Highlights nonconformity between procedures/guidelines and actual practice.
- Highlights barriers that have functioned and barriers that have not functioned.
- Enables analysis of underlying causes.

However, MTO has certain limitations that it is important to be aware of:
- Not suitable for analyses where accidents/undesirable incidents are due to purely technical or human errors.
- Difficult to illustrate the passage of time and incidents that occur in parallel.
- No clear rules regarding when to start and stop the course of events.
- It can be challenging to move from MTO to more in-depth analysis of underlying causes (from checklists/cause codes to analysis and interpretation).

d. The “human factor” perspective

This perspective argues that a human error is only a symptom of a system failure (Dekker, 2006). It proclaims that the “bad apple” theory is out-dated and does not contribute to improving the safety within an organisation, but rather pushes problems ahead of itself. The bad apple theory entails finding the scapegoat which is “guilty” of causing the incident. Instead of focusing on finding the causes that trigger incidents, we should rather endeavour to explain how the incident could happen and create learning through behaviour modification, without necessarily advising or imposing anything on more or less involved persons (Dekker, 2006).

Human Factors analysis (Lardner and Scaife, 2006) aims to find out why people make mistakes/errors. There are two main reasons – errors are either made intentionally, or errors are made unintentionally. Characteristic of the latter is that the person him/herself does not entirely understand that he/she has made a mistake or error. There are four main types of such errors:

1. Errors of memory (e.g. one does not remember all the steps in procedure)
2. Errors of perception (e.g. one hears nine instead of ten)
3. Errors of judgement (e.g. one thinks that one has enough space to overtake)
4. Errors of execution (e.g. one steps on the gas pedal instead of the brake)

This analysis can also be taken further in order to find so-called “performance changing factors”, which can be changed in order to avoid similar errors at a later date. For example, the gas and brake pedal can be placed further from each other in order to reduce the risk of error type 4.

A so-called ABC analysis can be carried out for intentional errors. Research shows that our Behaviour is controlled by the Antecedents of the accident and the Consequences. Here, we are talking about personal consequences, e.g. if the person can achieve an advantage by acting in the way that he/she does (e.g. consciously taking a shortcut).

In order to reduce intentional errors, the working conditions can be changed. When this relates to procedures, we can ensure that procedures are followed by:

- Having up-to-date, well-written, simple procedures

- Having good user involvement when making updates
- Having procedures that employees can easily find

We must also strive to have positive and immediate consequences when procedures are followed – and negative and immediate consequences when procedures are *not* followed – but remember the HOP principles (Appendix E).

e. AcciMap

AcciMap is a methodology which understands accidents as a result of loss of control over physical conditions/energy. When analysing accidents and undesirable incidents, the prerequisites for control, flow of information and the system's dynamic qualities must be highlighted.
AcciMap builds upon a socio-technical model, which means that actors from all levels (from the technical system to national/international level) are included in the analysis.

AcciMap is a methodology which shows correlations, rather than causal chains. The analysis process starts with a selected critical incident. Function and outcome boxes are used to describe the course of events and physical conditions, and to chart the circumstances and functions that have influenced the incident. Instead of causal chains, influence arrows are used to link individual elements together. The analysis provides a basis for assessing barrier breaches/weaknesses in the system.

Advantages of AcciMap include:

- Can be used for all types of systems.
- Can identify a large number of risks.
- States which barriers have functioned and which have failed (both hard and soft barriers).
- Specifies who has responsibility for developing, adapting and maintaining barriers.
- Clear rules for the start and stop time for the analysis.

Disadvantages of AcciMap include:

- Not the best method for mapping the course of events.
- Not so good at suggesting risk-reducing measures.

f. TRIPOD

The basic idea behind the Tripod methodology is that it aims to identify the underlying weaknesses that lead to incidents, while promoting an understanding and better control of these factors in order to prevent future incidents. Tripod focuses on systematic factors and how management decisions can lead to hazardous conditions at the workplace. Tripod consists of two tools – Tripod Delta, an independent proactive tool in the form of a survey, and Tripod Beta, a reactive approach and a systematic tool for the analysis of incidents/accidents. Several incidents can be analysed and the findings collated so that important barrier weaknesses can be identified. Research and examples from the industry show that the use of Delta (proactive) can provide the same findings as the use of Beta after incidents have occurred. Incidents can therefore be eliminated before they take place.

Tripod uses both "human factors" models and barrier analysis. Emphasis is placed on understanding organisational weaknesses that lead to failures in the systems and barriers that should prevent errors being caused by people and equipment. This might include the way the work is organised, the execution of maintenance, the way equipment/tools are designed, as well as ergonomic conditions. These environmental conditions are called latent errors, because they are present long before an incident takes place. The tripod theory identifies several parameters that are critical for the degree of control an organisation has over its processes. These are called Basic Risk Factors – BRF. The figure below shows how both Tripod Delta and Beta can be used to find latent errors that in a given situation may result in an HSE incident.

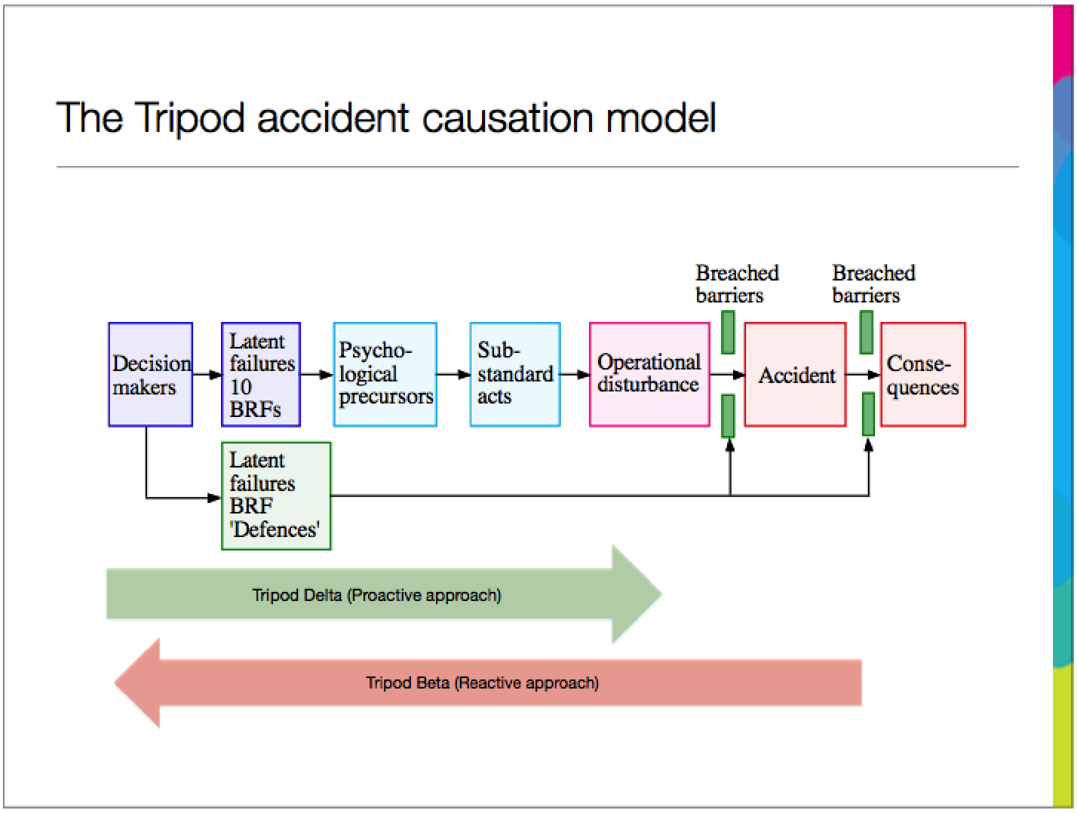

Figure B2: Tripod Delta and Beta

<u>Basic Risk Factors:</u>
Design
Tools and equipment
Maintenance management
Tidiness and cleanliness
Procedures
Training
Communication
Conflicting goals
Organisation
Error-reinforcing factors (external and internal influence)
Preparedness (does not cause incidents, but influences the consequences)

g. The loss causation model

The loss causation model can be valuable in the structuring and analysis of causal relationships for both a larger sample of incidents, as well as a single or a smaller sample of accidents (from 2-5).

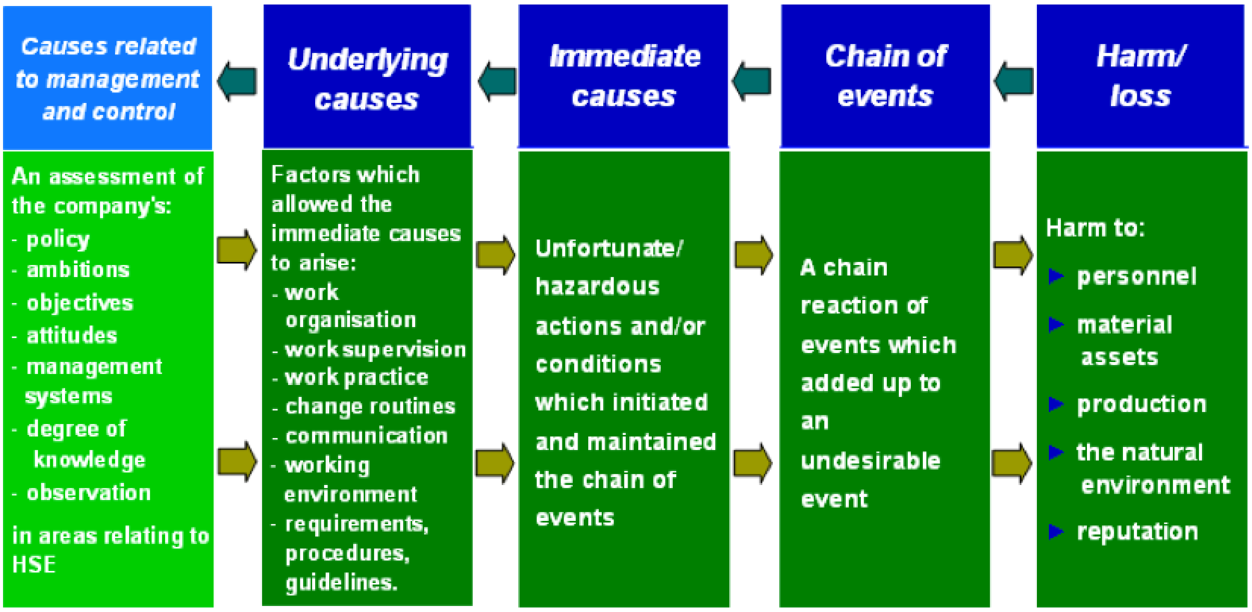

Figure B3: The loss causation model

The model outlines causal relationships from right to left in the figure, and a chain of incidents from left to right. In an analysis it is usual to start from the right side and work backwards through the chain of events and causal relationships. The question "why?" is asked when moving from one step to the next. The use of STEP and the loss causation model in combination often provides a good analysis result.

Advantages of the loss causation model include:

- Can be used for all types of systems.
- Suitable method when causal relationships are complex (human, technical and organisational factors are involved).
- Well-suited to the classification of causes (cause codes/checklists exist).
- Highlights nonconformity between procedures/guidelines and actual practice.
- Well-suited for the analysis of causes relating to management and control.

Limitations of the loss causation model include:

- No clear rules regarding when to start and stop the course of events.
- The use of cause codes and checklists instead of open and free dialogue will have a restrictive effect on the results.

h. Fishbone diagram

The fishbone diagram is used to identify and analyse all the potential and/or actual causes (or inputs) that may result in a safety problem (effect or output). Causes are arranged in accordance with their level of significance or details, which results in a delineation of relationships and hierarchy of incidents. This can be useful when looking for underlying causes, identifying areas that may contain problems, and comparing the relative significance of various causes.

The diagram may incite the development of an in-depth and objective presentation and can ensure that all participants are on the right track. The diagram can also counteract half-finished and/or hasty solutions, and shows the relative significance and relationships between the various parts of a single problem.

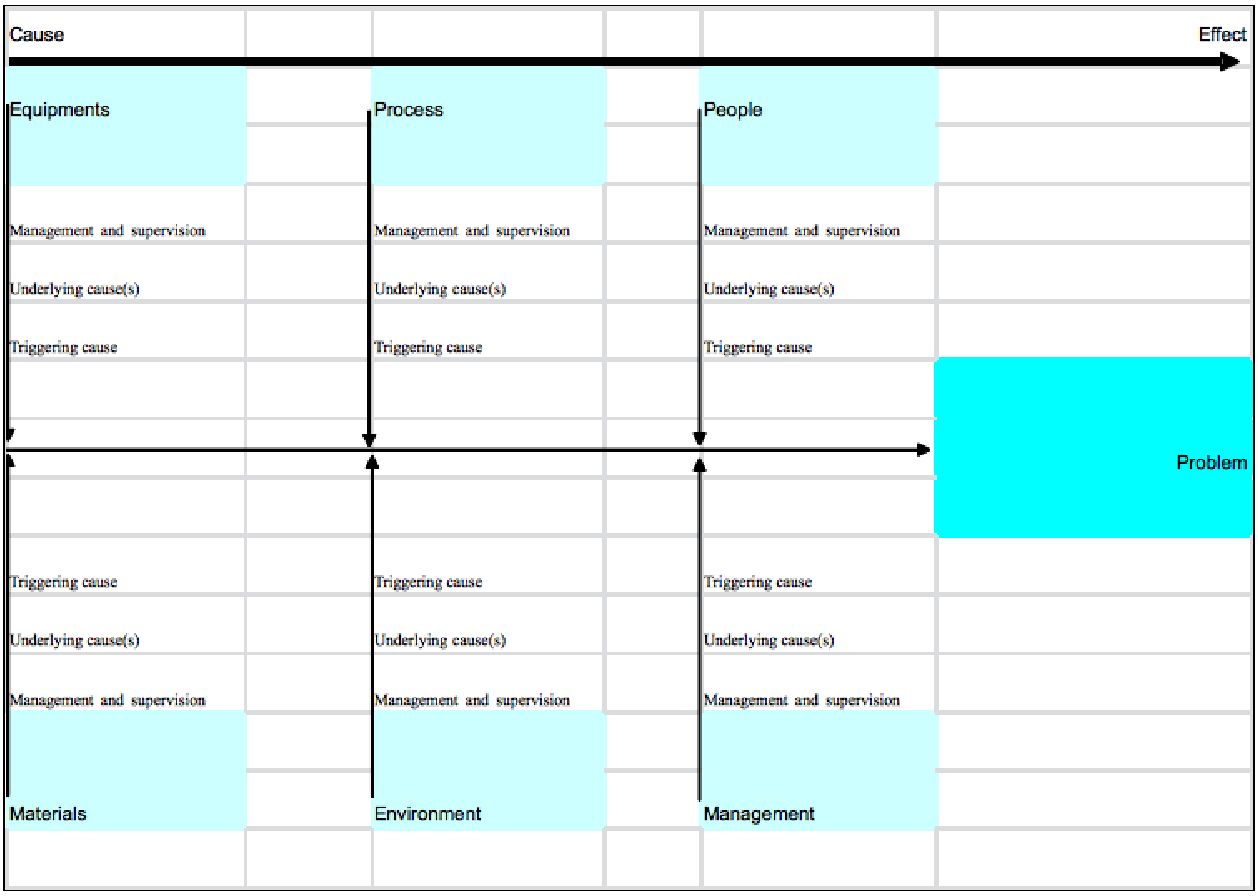

Figure B4: Fishbone diagram

The process in a fishbone diagram may be as follows:

1. Ensure that everyone agrees on the effect or problem prior to starting the analysis.
2. Be concise.
3. For each node, identify what you believe may be its causes, and add them to the diagram.
4. Follow each line of causal relationships back to the root causes.
5. Consider moving relatively empty branches onto others.
6. Consider dividing up crowded nodes/departments.
7. Consider which underlying causes are most probable in order to closely follow them up.

i. Fault tree analysis (FTA)

An alternative approach to understanding the mechanisms in accidents is to analyse the accident causes in the form of logical connections between incidents and conditions in the system. This can be done by creating a fault tree.

A fault tree is a logical diagram which shows the relationship between system failure (a specific undesirable incident in the system) and failure in the system's components. Fault tree analysis is a top-down approach. The diagram consists of symbols which represent input incidents in the system, the relationship between these and the system status. The graphical symbols show connections, called logic gates. The undesirable incident constitutes the top of the fault tree diagram, and the various component errors constitute input incidents.

A fault tree diagram is used in the analysis of an individual incident. If several incidents are to be analysed, several fault trees must be used.

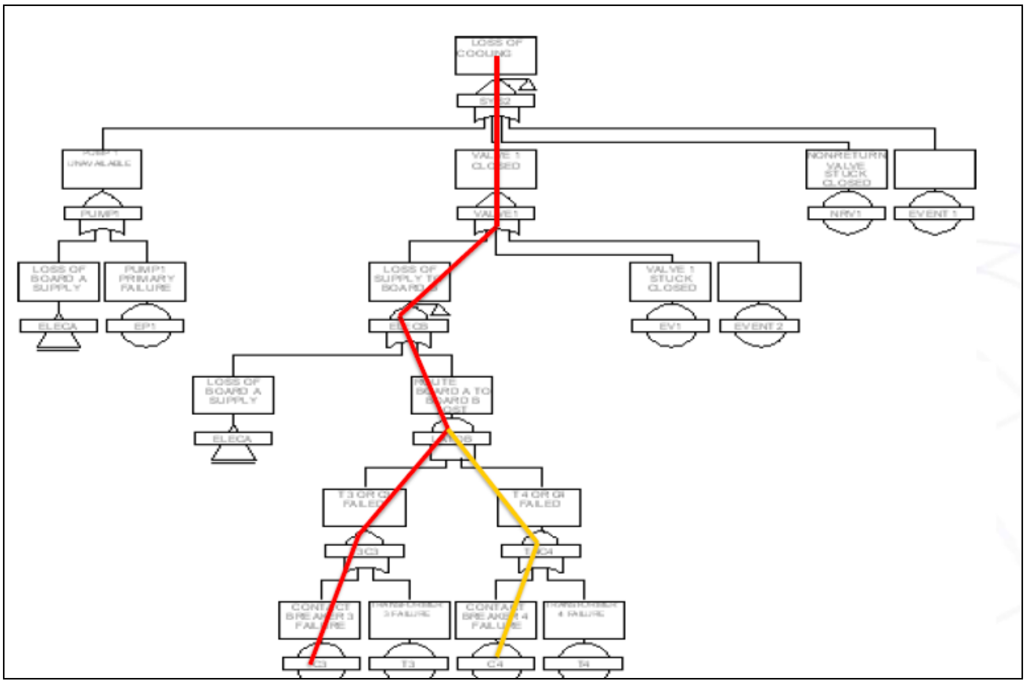

Figure B5: Example of a fault tree

The results of a fault tree analysis may include:

- A list of possible combinations of component errors/input incidents that will cause the top event
- Identification of critical components/incidents
- Uncertainties in the system (probable causes for the top event occurring)

A typical FTA can identify several underlying causes which had no impact on the top event occurring. It can be important that these causes are also followed up.

A usual way of modelling an FTA can be summarised in five steps:

1. Define which undesirable incidents are to be analysed.
2. Establish an understanding and knowledge of the system.
3. Construct the fault tree. Identify input incidents and analyse.
   The fault tree consists of "AND" and "OR" gates, which define the most important combinations of component errors/incidents.
4. Evaluate the fault tree.
   When the fault tree has been put together for a specific undesirable incident, it will be assessed and analysed to identify any improvements. Risk management is studied, and ways in which the system can be improved are found.

This step then becomes an introduction to the last step, which will be to control hazards. In short, in this step we identify all possible hazards that influence the system directly or indirectly.

5. Control of the identified hazards.
   The fault tree analysis is then tested in order to reduce the probability that the steps and the top event in the FTA can occur.

j. Affinity diagram and brainstorming

In an analysis of HSE incidents, questions and problems may arise which cannot be answered by studying statistics/data and investigation reports. Information and ideas may be available through other sources, such as the experience, knowledge, skills and competence of the personnel in the analysis group or the organisation. Individuals may also have observed practice which is not good and/or have ideas for improvements that have not been brought to the table.

Brainstorming and affinity diagrams are a method that can reveal all ideas and thoughts within a working group. The group's creative thinking is utilised, and the ideas are systematised in a structured and logical diagram. The method is simple and low cost, and the necessary materials are post-it notes or the equivalent, pens or markers and a large work surface (wall, table or floor).

The result of a brainstorming process may depend upon the knowledge and competence within the group, the openness of the culture and skills of the facilitator. The working group should consist of persons who have the necessary knowledge and skills to reconcile viewpoints. For efficiency, experience dictates that the optimal size of a group is between 4 and 6 persons.

The brainstorming process takes place by listing all proposed ideas. Creativity is encouraged by not allowing ideas to be evaluated or discussed before everyone has run out of suggestions. All ideas are regarded as legitimate, and it is often the most improbable that turn out to be the most fruitful.

Practical tips for successful brainstorming include:

- Ensure that everyone understands and is happy with the central question before you open the floor for ideas
- Give people a few seconds to note down some ideas before you start
- Give everyone a chance to express their ideas
- Encourage radical and relevant ideas
- Prohibit discussion and analysis of ideas in this phase
- Record exactly what is said. Clarifications should be made after everyone has run out of ideas
- Do not stop before the ideas become sparse. Allow ideas that are suggested late

Prepare an affinity diagram by sorting and grouping all the ideas into groups (by points of affinity):

- Quickly group ideas that are thought to belong together
- It is not important to define why they belong together
- Clarify the grouping of all ideas that are discussed
- Use an idea in more than one group if this is appropriate
- Assess the small groups. Do they belong in a larger group?
- Should the larger groups be split up?
- When most of the ideas have been sorted, titles can be added to each affinity group

Appendix C: Validation and statistical significance

The data that shall be used should be generally recognised or considered relevant through e.g. the involvement of employees, communication, transparency and independence regarding who has taken the measurements/the manner in which the data was obtained.

Validation

Validation of an analysis method involves verifying and documenting that the method is fit for purpose. The analysis method must be a procedure made in writing, which describes in detail how the analysis shall be carried out. The validation should say something about the method's accuracy, precision, uncertainty and independence.

Indicators/statistics are defined in order to measure a "phenomenon" (e.g. SIF, TRIF, gas leaks, dropped objects, acute emissions, ship collisions, etc.). It is important for the quality of the trend evaluation and analysis that there is as much overlap as possible between the indicator and the phenomenon.

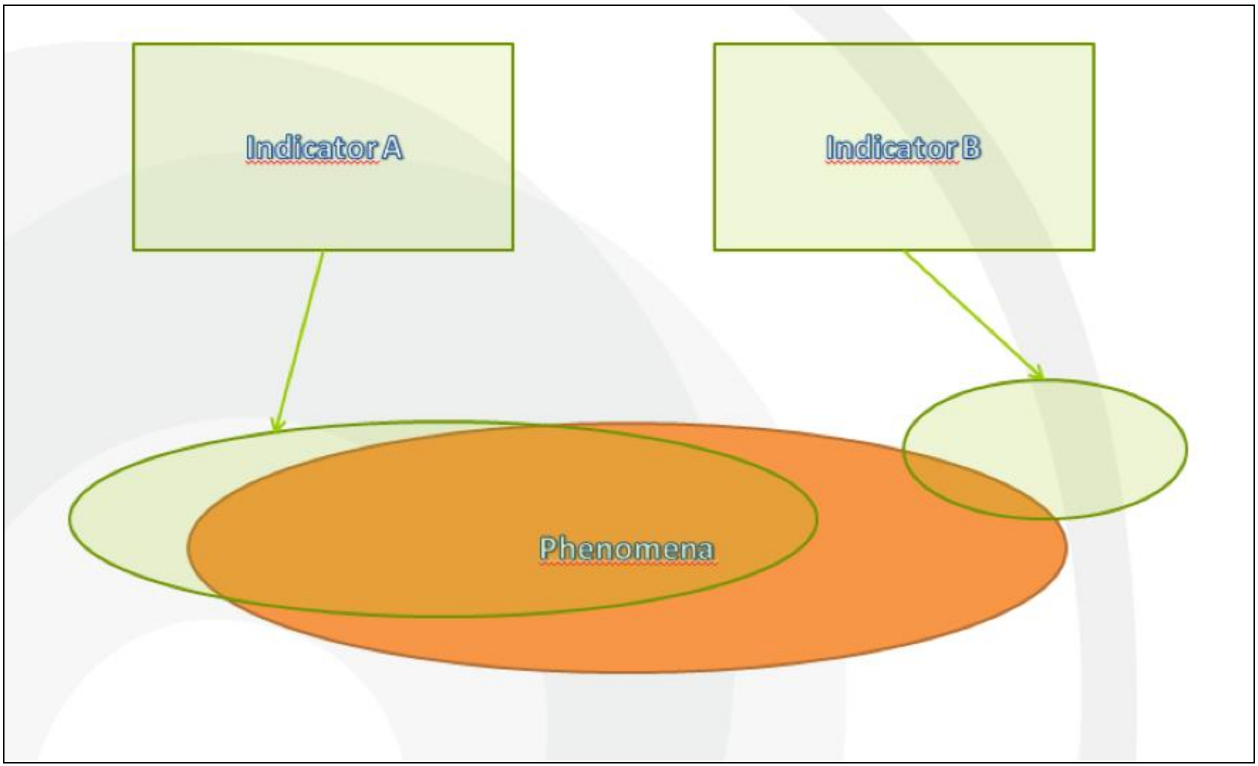

Figure C1: Indicator and phenomenon that shall be measured

Some considerations regarding the validity of HSE data:

- The HSE culture in the individual company and locally on installations varies
- Transparency and the encouraged reporting of relevant data provides more reports
- Previous reactions upon the reporting of similar incidents, e.g. a negative reaction upon the reporting of incidents, creates an increased threshold for reporting
- Reward schemes and the use of sanctions can both encourage and undermine reporting systems
- The use of different terminology creates confusion and uncertainty regarding whether one is simply comparing "apples with apples"

- The wish to interpret data in our own favour can be a problem, e.g. more reported incidents means that we have become better at reporting, while fewer reported incidents means that we have improved safety
- How do we compare different types of work, e.g. scaffolding and lifting operations with office work, or the drilling of high pressure/high temperature wells in deep water in areas with rough weather with production wells in shallow water in established fields and calm conditions?
- Work that is important in order to prevent major accidents, such as maintenance, provides a statistically increased risk of injuries. Through the unbalanced use of statistics and analysis, the reduction of this type of work may give improved statistical data, even though the risk of a major accident increases.

It is important to remember to verify that the data has been reported correctly, that the search parameters are correct, and that the measurement parameters are understood, etc.

Statistical significance

Statistical significance is a term that is used to describe the probability that something is the result of chance. The result of the statistical analysis is deemed statistically significant if it is unlikely that the result has occurred by chance. In a statistical context, the term significance does not necessarily indicate that something is important, as it often does in other contexts. It only indicates that something is probably not a random occurrence. The term “significance level” is often used to describe how statistically significant results must be in order to be acceptable.

If one has large quantities of data with small variations, changes may be statistically significant even though the change is small. On the other hand, in a limited amount of data with large variations, seemingly large changes may be statistically insignificant (ref. RNNP – Risikonivå norsk petroleumsvirksomhet/Risk levels in Norwegian petroleum activities).

Appendix D: Normal distribution and standard deviation

The normal distribution can be observed in several places in nature and society, and several incidents can be described in great accuracy by the normal distribution. If data is normally distributed, 68% of the observations are within a distance of a standard deviation S from the average, and 95% of the observations are within a distance of 2S.

The Gaussian normal distribution is a model that describes many distributions of realistic data in an accurate way. Theoretically, the normal distribution is defined by a special type of function, an exponential function. The graph of this function is a bell-shaped, symmetrical curve, see below.

The normal distribution is indisputably statistics' most important distribution. It is closely linked to a mathematical result known as the central limit theorem. The result states that the sum of a large number of independent random variables is approximately normally distributed under certain general conditions, regardless of the distribution these variables had originally. This means that the normal distribution can be observed in several places in nature and society, and several incidents can be described with great accuracy by the normal distribution.
Standard deviation is a widely used measure of dispersion. The motivation for this comes from normally distributed data. Then, 68% of the observations are within a distance of a standard deviation S from the average, and 95% of the observations are within a distance of 2S.
We must not assume that small quantities of data are normally distributed. Neither are many large datasets. However, in other cases the theoretical normal distribution will accurately reflect reality.

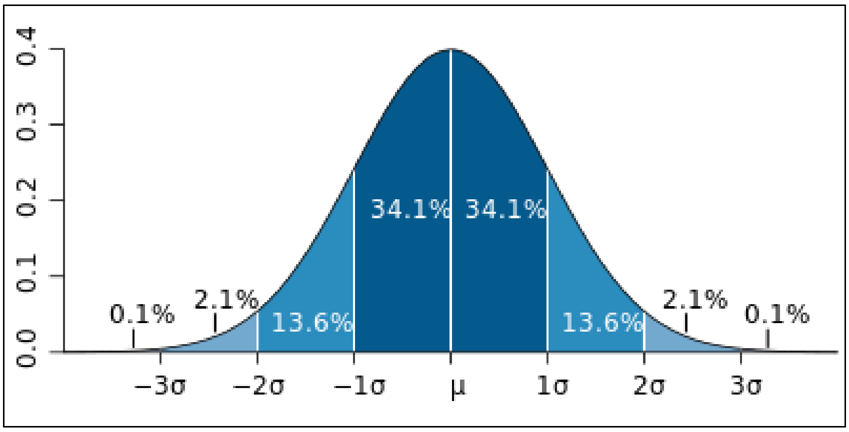

Figure D1: Normal distribution

Appendix E: Human and Organisational Performance (HOP)

The energy sector, together with other high-risk industries, have adopted the HOP principles to improve practices relating to safety management. HOP is the way in which people, technology, work processes and organisations interact as a system. Norsk Industri have good information about HOP on their website[4].

The HOP principles build upon some foundational assumptions and principles. HOP is a proactive approach to increasing the level of safety, and represents a change in direction in our approach to learning and improvement:

The 5 HOP principles:

1. It is normal to make mistakes so we must reduce the consequences.
2. Blame fixes nothing. We must choose between blame and learning.
3. Learning is the key to improvement. Theory must be transformed into practice.
4. Context drives behaviour. Work is guided by what seems reasonable.
5. How leaders respond matters – not just their words, but also their actions.

The HOP principles can also be used when following up observations – a key part of HOP is identifying error traps (see the examples below). An example might be observations relating to quality and adherence to the work permit process. One can then establish a learning group of 5 to 10 persons in one or more workshops, which examine how the job would normally be performed versus how it should be performed. Representatives from both operators and contractors/suppliers should be included here.

Learning groups is a group-based method intended to strengthen learning, and a core element of the HOP philosophy. Learning groups shall focus on operational learning from those who perform the work and strive to manage conditions (error traps) that make it difficult to work safely and proactively.

Examples of error traps:

Technical error traps	**Task-related error traps**
- Faults on equipment or systems - Insufficient documentation - Unclear instructions, labelling or signals - Inappropriate tools or poor accessibility - Noise, lighting conditions, temperature and air quality	- Unfamiliar tasks - Unpredictable tasks - Complex tasks - Limited time - Mundane repetitive tasks
Organisational error traps	**Individual error traps**
- Unclear roles and responsibilities - Task conflicts - Communication/collaboration issues - Staffing and resource management - Work organisation	- Insufficient training/competence - Lack of experience - Lack of rest - Health issues - Stress

Appendix F: References and recommended literature

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