Recommended practice for investigations and inquiries into HSE incidents

Working Together for Safety Recommendation 029E/2020

SfS
Samarbeid for Sikkerhet

Prepared by the Working Together for Safety Working Group: **August 2020**	Revision: **Revision 03**	Working Together for Safety Project Manager: Hugo Halvorsen Hugo Halvorsen (Sign. On file)
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1 Introduction

The main purpose of investigations and inquiries following undesirable HSE incidents is to identify experience that can contribute to learning and prevent the incident from recurring.

In accordance with the Management Regulations[1], *"The responsible party shall ensure that hazard and accident situations that have occurred and that may lead to or have led to acute pollution or other harm, are recorded and examined in order to prevent recurrence. Situations that occur frequently or that have great actual or potential consequences shall be investigated. Criteria shall be set for which situations must be registered, examined and investigated, and requirements shall be set for the scope and organisation.* Furthermore, the guidelines to Section 20 details what the investigation should clarify:

The employer (or the main enterprise) is responsible for ensuring that activities are planned and organised in a way that ensures that Section 20 of the Management Regulations and accompanying guidelines are taken into consideration. Planning must ensure that the company has the necessary equipment and systems in place to register, process and archive HSE incidents. The employer must also ensure that the individuals involved in this process have the necessary competence to carry out their assigned work tasks[2]

2 Purpose of the recommendation

The purpose of this recommendation is to provide knowledge of processes and methods that can be used in the execution of an effective, independent investigation or inquiry. The recommendation may also help others who are involved in or affected by an investigation to better understand the process.

This recommendation uses the term "investigation", but the same methods and principles may also be used in inquiries into less serious incidents. It is up to the individual company to differentiate the scope of inquiries and investigations.

3 Changes from the previous version

This recommendation contains most of the text from the previous version, but level of detail has been reduced and parts of the text has been moved to the appendix list.

4 Facilitating investigations

In order to comply with the requirements of the Management Regulations, the companies should have an established and documented system in place for the investigation of incidents, so that an investigation can be initiated as soon as possible when necessary. In addition to having the necessary competence (see Appendix 2), the company should have established a process description, clarified roles and responsibilities, and ensured that individuals have completed the necessary safety courses, etc.

Examples of what should be in place and the criteria that should be used as a basis for investigation:

- Requirements regarding which types of HSE incidents shall be investigated and at what level.
- For hydrocarbon leaks, the potential course of events and consequences should be mapped independently of ignition probability (ref. the guidelines to Section 20 of the Management Regulations).
- Incidents for which investigation is regarded as necessary in order to identify hazardous conditions that will not be identified through normal registration, reporting and case processing procedures.
- Management of HSE incidents in the borderline between internal and external suppliers (eg. Floating drilling rigs, vessels and helicopters)

If an incident has several actual and/or potential consequences, the incident's severity shall be determined by the most serious potential consequence (ref Appendix 1C).

5 Planning the investigation

5.1 Decision to carry out an investigation

In addition to determining if an incident should be investigated using a severity categorisation matrix; other criteria can also be used:

- Frequently occurring HSE incidents or recurring incidents within a certain incident type, activity, location, etc.
- The learning potential to be gained from carrying out the investigation.
- Request to carry out an investigation from the line organisation, AMU etc..

The management decides whether an internal investigation shall be carried out, and if so at what level. In general, the more severe the incident, the higher the level at which the investigation should be carried out within the organisation.

Investigations should be led by the company that is responsible for the installation/facility or the geographical location at which the incident occurred. The management shall appoint an investigation leader and a mandate for the investigation should be prepared. Appendix 2 contains a checklist for establishing the investigation group and a mandate example.

5.2 Obtain Evidence and information

The collection of data and technical evidence should start as early as possible and include photographs that illustrate the situation directly following the incident.

The relevant area should be cordoned off as soon as the emergency response situation makes this possible. No clearing up or other operations may be carried out, other than that which is necessary in order to prevent further accidents. Evidence that may be lost or misplaced should be secured immediately. It is the owner of the incident's responsibility to do this. Examples include information about lighting, temperature, weather, spills, stains, gas concentrations, process logs, etc.

Appendix 3 contains a checklist for the start-up and planning phase.

6 Execution of investigation

This chapter describes the process from when the investigation team is appointed, through the collection of data, analysis and conclusions, to summary and temporary measures.

Work aids
It can be advantageous to create a restricted electronic data area with access limited to the members of the investigation team. This area can for example be used to store action logs, interview lists, time logs, investigation logs, report templates and other useful documents such as MTO and STEP diagrams, etc. An investigation log can be used to register the progress of the investigation. Appendix 4 includes template examples.

Information security
Information should not be released before the investigation work has been completed, unless it is necessary to provide information about matters that cannot wait until the work has been completed. In such situations, the investigation leader communicates with the client and emphasises that the observations are preliminary and may change as more information becomes available.

Communication with the client
It is important that the investigation leader informs the client of and clarifies any problems as early as possible, so that the client and investigation leader agree upon the course of the work and any changes to the schedule. This also covers conditions that may affect the original mandate. If the assignment is at a given level, and throughout the course of the investigation it is found that the severity of the incident dictates investigation at a higher level, the client should be informed of this in writing as soon as possible.

6.1 Collection of data

There will usually be a significant amount of information available for the investigation team, particularly in the early stages. It is important that the investigation team works efficiently, objectively and methodically in order to ensure that all facts and details are retained. No hypotheses or conclusions should be made prior to the analysis stage of the investigation.

The mnemonic ‘4P’ can be a useful aid in remembering what data shall be collected; i.e. that **P**eople, **P**lant, **P**laces and **P**rocedures shall be surveyed. An overview of who was where, which equipment and tools were being used and their location, and which procedures relate to the activity that was being undertaken when the accident happened should be obtained. The collection of technical evidence (damaged equipment/objects found at the work site, etc.) also comes under the “4P” areas.

Data can be collected in several different ways, such as through site inspections, interviews and document studies (logs, drawings, plans, etc.).

It is especially important that information stored in data systems (such as system logs and backups) are collected as early as possible, since the quality of such information may be reduced over time or the information may be deleted.

Site inspection
The first step in the field work will often be a site inspection of the incident site. The incident site should be thoroughly photographed and the necessary distances and dimensions, etc. should be measured and recorded. If activities at the site have been stopped due to the investigation work, the incident site and equipment should be released as soon as possible. If necessary, a reconstruction of the incident may also be arranged.

Interviews
A significant amount of information about the incident often comes from interviews, and it is therefore important that these are professionally conducted by persons with competence within interview technique.

The most important aspect of an interview is to start with an open mind and allow the interviewee to give a free account of the incident in his/her own words. At least two persons from the investigation team should participate in the interviews. All interviews shall be carried out professionally and objectively, and the investigators shall act in a calm and considerate manner.

More information can be found in Appendix 4 – Interviews.

Document review
In addition to the site inspection and interviews, the reviewing of relevant documents is an important source of information in an investigation. Here, the term ‘documents’ has a broad definition and includes alle drawings, logs and documentation, including governing documents that has relevance for the incident.

6.2 Analyses

When data from the incident has been collected, the findings should be systematised and analysed to identify:

- Events leading up to the incident
- Barriers
- Causes
- Possible measures

It is important that the analyses are carried out from an MTO perspective. This means that the events leading up to the incident, causal relationships, any breached barriers and possible measures should be considered on the basis of human, technological and organisational conditions, both separately and with a focus on the interaction between these. The analyses should focus on the barriers and causes (critical factors) that are decisive for the incident.

Appendix 6 provides and overview of some analysis models and methods.

Incident analysis
The first part of the analysis work is to establish an overview of the events leading up to the incident that is as correct as possible. The most appropriate method here will be to start with the incident and work back in time. The most concrete causes will typically be discovered “close” to the incident, while the relationships typically become more diffuse the further away from the incident one gets. In many cases, two or more parallel chains of events leading up to the incident will be discovered, which meet either in connection with the incident itself, or shortly prior to the incident. It may sometimes be necessary to reconstruct incidents in order to support analyses and assumptions.

It is critical that the investigation work is based on fact. Where assumptions are made, these should be stated explicitly in the investigation report. How far back in time the events leading up to the incident should be traced varies, but attempts should be made to go as far back as is necessary to include all relevant conditions that have clearly influenced the incident.

Barrier analysis
The barrier analysis shall identify technical, operational and organisational barriers (breached, weakened and missing barriers). Which barriers have functioned and/or limited the scope of the incident shall be identified.

When breaches of barriers or missing barriers are discovered, the cause for this must be identified. Such causes may be immediate or underlying. For more information about barriers, see the Petroleum Safety Authority’s booklet “Prinsipper for barrierestyring i petroleumsvirksomheten (Principles for barrier management within petroleum activities) (20.01.2013)”.

Causal analysis

The causal analysis is often carried out in parallel with the barrier analysis after the events leading up to the incident have been established. The causal analysis shall identify immediate and underlying causes relating to the individual incident elements. The immediate causes are usually limited to one or a few causal relationships that are closely connected to the incident (e.g. a wrong action or a technical failure), while the underlying causes may be divided across several different causal relationships at different levels within the organisation.

It can be very useful to use a systematic approach in the search for underlying causes. For example, pre-defined methods and models can be used, in which typical underlying causes, or categories of these, are listed. Such a systematic approach increases the possibility of identifying all relevant causal relationships. However, this does not prevent the investigation team from looking for explanations outside the pre-defined framework.

Some causal categories may be termed *structural*, which means that they are relatively tangible and therefore relatively unproblematic to identify and to suggest measures in connection with. However, emphasis should also be placed on identifying underlying causes of a more cultural nature, since these often reveal themselves to be equally important in fully explaining the background to a chain of events leading up to an incident.

Analysis of measures

The purpose of measures is to prevent similar incidents from occurring in the future. Effective measures are therefore completely dependent upon good incident, causal and barrier analyses. Measures relating to immediate causes will typically have a more local/specific effect than measures relating to underlying causes. It is important that the suggested measures have the necessary connection to the actual causes that are identified throughout the course of the investigation.

It can however be useful to consider recommended measures in the light of similar measures that have already been recommended as a result of previous investigations. Here, for example, it may be appropriate to combine different measures, or to at least ensure that two or more measures do not conflict with one another.

When suggesting measures, probability-reducing measures (i.e. measures that shall prevent incidents from occurring) shall be prioritised over consequence-reducing measures (i.e. measures that limit injuries/losses).

The recommended measures should be concrete and achievable. They should be able to endure over time (independently of initiative or follow-up) and be easy to communicate. They should be SMART: **S**pecific, **M**easurable, **A**chievable, **R**ealistic and **T**ime-bound.

Note: There is a trend where the investigation team does not recommend actions. Instead “Learning Teams” or “Causal Learning” methods are used. See ref 3.

6.3 Summary meeting

Before leaving the facility or installation, a summary meeting should be held with the management of the investigated unit. The agenda for this meeting can be as follows:

- Status of the investigation work
- Recommendations for immediate measures
- Plan for remaining work

If preliminary findings and results are discussed at this meeting, it is important to communicate that the presented information is based on the investigation team's preliminary work, and that it may change later.

7 Report writing

7.1 Prepare report

All investigations should be documented through a written report. A report template can be used (see Appendix 5 D – Investigation report).

The investigation report shall respond to the mandate and be prepared in accordance with the company's procedures. The preparation of the report usually starts while the investigation is on-going as part of the work to systematise and safeguard information. Recommended measures should be based on the identified causes.

At a minimum, the report should include:

- A summary of the main points
- Details of the investigation team's members, mandate and team member signatures
- Response to the mandate
- Diagrams and/or models that explain methods and conclusions
- Suggested measures
- Relevant attachments

Elements that should also be included in the report:

- Conflicting witness statements should be included in the investigation report.
- Personnel who have been involved in the incident shall remain anonymous.
- If the investigation report is not written in English, a short summary should be included in English directly following the report summary.
- If changes have been made with regard to the original mandate, this should be documented in the mandate chapter of the investigation report.
- Severity as classified based on actual and potential consequences.
- Information included in the report's front page, header and footer should be entered in accordance with the company's document management system.

If the investigation identifies serious conditions that have not had a direct impact upon the course of events leading up to the incident, these shall be reported to the client and/or responsible manager regardless of whether or not these conditions are described in the report.

7.2 Quality assurance - consultation

The draft report should be subject to a quality control prior to completion. The investigation leader can do this by presenting the draft report to a fixed, appointed review panel. If no fixed, appointed management panel exists, the client and investigation leader together appoint who shall participate in the consultation, e.g. personnel in involved units, legal personnel, other internal units and external companies involved in the incident.

The investigation team, through the investigation leader, carries out the consultation and receives comments directly from those involved in the consultation process. After the consultation process, the received comments are reviewed by the investigation team. The team decides which comments shall be accepted before the final report is prepared and sent to the client, together with any appropriate presentation material. Any disagreement within the investigation team regarding conclusions or measures shall be stated in the report.

The quality control of the investigation report should include the report's investigative quality and appropriate descriptions of facts, risks and causes. It must also be ensured that the recommended measures cover the identified risk areas. Simple language should also be sought to be used.

7.3 Completion of final report

When the report has been subject to consultation and reviewed, the final report can be prepared. It is approved and signed in accordance with the company's guidelines (the investigation leader usually signs on behalf of the investigation team).

All members of the investigation team should state their endorsement of the report before it is signed by the investigation leader. If one or more members disagree with parts of the report, this must be documented in the report. Following acceptance of the final report by the client, the report is archived and distributed in accordance with the company's routines.

8 Follow-up and learning

When the investigation report has been approved by the client, all recommended measures are registered in the company's system for the follow-up of undesirable incidents. The client decides which of the recommended measures shall be implemented. If the client decides not to implement a recommended measure, the reason for this is documented in the system for the follow-up of undesirable incidents.

The client should also consider whether any measures in addition to those recommended in the report should be implemented, and when and how these shall be executed. The client shall also approve who is responsible for the measures. The persons appointed as responsible for the measures should be informed and consulted in advance so that realistic implementation deadlines can be set. This will also ensure that those responsible for the measures attain a full understanding, and that time and resources can be allocated to ensure that the measures are implemented in a high-quality manner.

The measures are closed in accordance with the company's routines. It is important that measures are not closed if they are simply transferred to another list (e.g. plans for modifications). This is to ensure that the measures are actually implemented. Internal audits are also recommended to quality assure that the measures have been appropriate.

Investigation reports with overviews of adopted measures and lessons learned should be presented to the management and in relevant forums, e.g. the Working Environment Committee (AMU) and can also be shared in other forums such as meetings with suppliers, manufacturers of involved equipment, license partners, etc.

It is recommended that a one-page bulletin (lessons learned) is created for all serious incidents. The companies should internally facilitate familiarisation with the one-page bulletin and ensure that it is used in a proactive way so that learning from the incident is as optimal as possible. For example, this can be done through relevant meetings.

The bulletin should contain the following details:

- A short description of the work activity and events leading up to the incident.
- A description of what happened and the consequences.
- Relevant lessons learned
- Illustrations
- Reference or link/pointer to the complete investigation report

Externally, the bulletin can be made available for example through common websites/portals with search functions for easy retrieval and systematisation. Depending on the assessed usefulness, in some cases it can be appropriate to present the incident through an interactive animation.

If the investigation uncovers weaknesses in equipment that may represent a danger to others, a "safety alert" should be sent out to the manufacturer/supplier as well as relevant networks such as Norwegian Oil and Gas Association's forums.

It should be noted that there is and increasing use of alternative investigation methods[3] (e.g. Causal Learning and Learning Teams) to facilitate improved learning.

9 Abbreviations

AMU	Working Environment Committee (Arbeidsmiljøutvalg)
AT (WP)	Arbeidstillatelse (Work permit)
DFU	Definerte fare- og ulykkessituasjoner (Defined hazard and accident situations)
HF	Human factors
HFAT	Human Factors Analysis Tool
HMF	HSE Managers Forum (Norwegian Oil and Gas Association)
HVO/VO	Senior safety representative/safety representative
IFE	Institutt for Energiteknikk (Institute for Energy Technology)
MTO	Man, Technology and Organisation
Ptil (PSA)	Petroleumstilsynet (The Petroleum Safety Authority)
RNNP	Trends in the risk level in petroleum activity
RUH (RUI)	Rapport Uønsket Hendelse (Report Undesirable Incident)
SJA	Safe Job Analysis

10 Definitions and explanations

Underlying cause:
Conditions or actions that create situations or environments that make the immediate cause(s) of the incident possible.

Barriers:
Technical, operational and organisational elements that individually or in combination shall reduce the probability of concrete errors, hazards and accident situations occurring, or which limit or prevent damage/accidents (ref. Trends in the risk level in petroleum activity, RNNP). A barrier's robustness is characterised by its ability to carry out its intended function over time.

Immediate cause:
A relationship or action which triggers the incident.

Incident owner:
The incident owner is the manager of the unit, department or activity where the incident has taken place.

HSE incident (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.

Human factors:
All factors that may influence people and their behaviour (www.hse.gov.uk/humanfactors/)
Human factors refer to environmental, organizational and job factors, and human and individual characteristics, which influence behaviour at work in a way which can affect health and safety.

Investigation:
A formal process that shall map the course of events leading up the incident and its causes and consequences, and identify effective corrective and preventive measures. The investigation is carried out by an appointed independent team on behalf of the company's management.

Mandate:
A formal description from the client, which describes the scope of the investigation or survey and which provides authorisation to undertake this. The mandate shall be agreed upon with the investigation leader.

Causality:
Causality is about the relationship between cause and effect. Common to all causal relations (cause-effect relationships) is that:

- Incident A (the cause) causes incident B (the effect).
- Incident A occurs before incident B in time (chronological asymmetry).
- Incident A is always followed by incident B (consequence).

11 References

1. The management regulations
2. The activities regulations § 21 (with supporting guidelines).
3. «Læring etter hendelser» (Learning from incidents), Chapter 6.3 in report to Safety Forum from tripartite group. Published November 11 2019.
4. SfS recommendation 035E Statistics and analysis of HSE incidents
5. SfS recommendation 043E Learning from incidents

12 Recommended literature

Bento, Jean-Pierre (2001). *Menneske–teknologi–organisasjon. Veiledning for gjennomføring av MTO- analyser.*

Hovden, J., Sklet, S and R.K. Tinnmannsvik (2004). *I etterpåklokskapens klarsyn: Granskning og læring av ulykker.* In Stian Lydersen (ed): Fra flis i fingeren til ragnarok – tjue historier om sikkerhet. Trondheim – Tapir Akademiske Forlag.

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PTIL (2013): *Prinsipper for barrierestyring*, PTIL sine hjemmesider

IFE/HR/F (2009/1406): *Vurdering av organisatoriske faktorer og tiltak i ulykkesgransking*

SfS Recommendation 035E (2013) *Statistics and analysis of HSE incidents and data*

SfS Recommendation 043E (2019) *Learning from incidents*

Weick & Sutcliffe (2001) *An organizational culture of mindfulness*

Appendix 1 Governing documents for investigations

The company should establish a governing document which provides a detailed description of incidents that are relevant to the company. The selected limits for the classification of incident severity should be described in this document. The purpose of the document is to ensure the correct registration, reporting and follow-up of undesirable incidents, and to determine the criteria for the reporting and investigation of undesirable incidents and conditions.

With reference to the above-mentioned governing document, the company/production unit should prepare dedicated matrices for the categorisation of undesirable HSE incidents (injuries/losses, courses of events or conditions) which are relevant to the organisation. RUIs which are categorised as approaches or conditions provide a basis for the assessment of potential damage or loss. The matrix shall have columns for relevant types of undesirable incidents with accompanying limits for determining their severity.

The incidents can be classified in accordance with a consequence/incident type matrix and in accordance with a risk matrix. Actual consequences (potential severity) and how often the relevant type of incident happens determine the risk potential of the incident.

Appendix 1A Matrix for the categorisation of HSE incidents
The potential (possible injury/damage) is determined by what would most probably have happened under slightly different circumstances. An incident may have several outcomes within the incident/damage category in the categorisation matrix, and therefore several checked outcomes. Of these, it is the item with the highest possible incident/damage category that determines the severity in the categorisation matrix and which may be transferred to the risk matrix for the classification/determination of risk factors.

Assignment level
After the incident has been categorised/classified in accordance with the company’s matrix/matrices, the assignment level for the investigation is determined. In general, the more severe the incident, the higher the level at which the investigation should be carried out within the organisation.

Example matrix for the categorisation of undesirable incidents

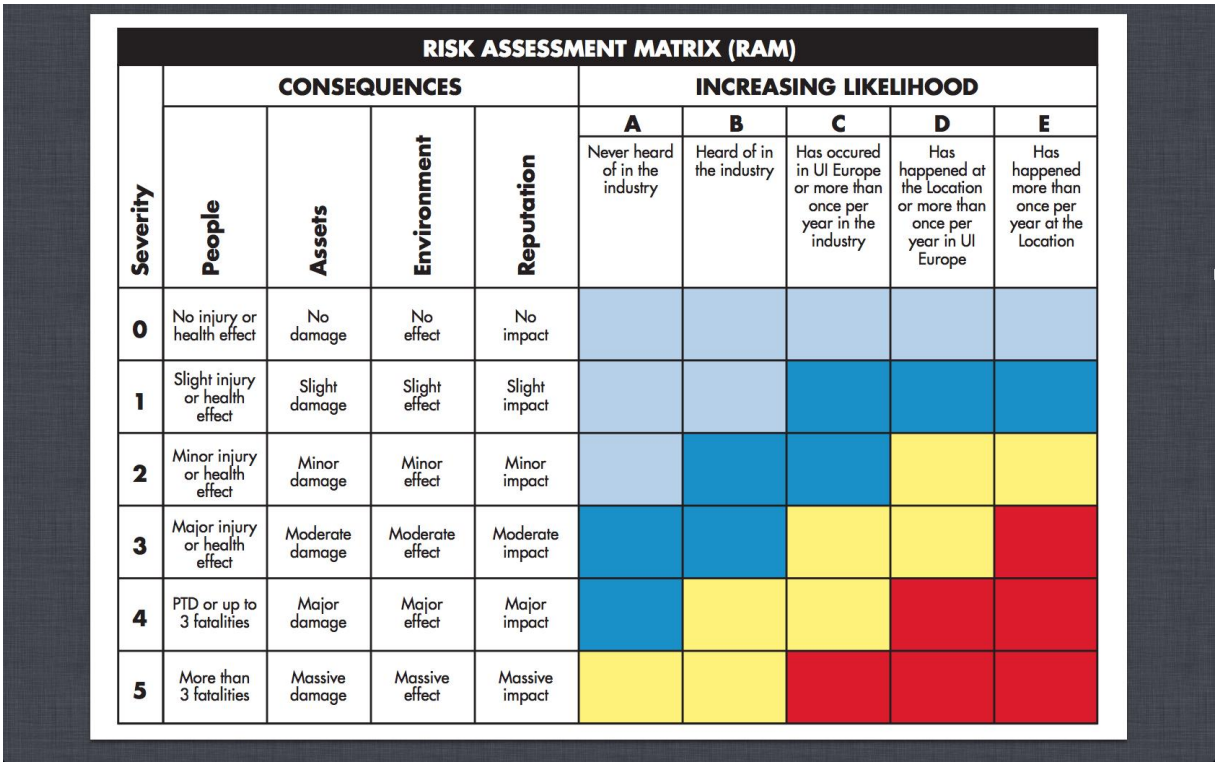
Alvorlighetsgrad	Personskade		Arbeidsrelatert Sykdom(ARS)		Oljeutslipp		Utslipp Kjemikalier		Olje-/gasslekasje		Brann/ eksplosjon		Svekking/bortfall av sikkerhets-funksjoner og barrierer		Sikringsbrudd		Produksjons tap		Materielle skader og andre økonomiske tap	
	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig	Faktisk	Mulig
1	Død		Arbeidsrelatert sykdom som medfører død		Mer enn 1000m³		Svart > 100m³ Rød > 1000m³ Gul > 1000m³		Mer enn 10 kg/s		Store deler av innretning eksponert		Hele innretning er truet		Terror, kidnapping, trusler, korrupsjon		Produksjon stans mer en 10 dager		NOK 10 mill	
2	Alvorlig fraværsskade		Alvorlig arbeidsrelatert sykdom		100m³ -1000m³		Svart > 10m³ Rød > 100m³ Gul > 100m³		1 – 10 kg/s		Mindre deler av innretning eksponert		Deler av inntetning er truet		Innbrudd, Skadeverk, Tyveri, Bestikkelser NOK 1 mill		Produksjon stans mer en 5 dager		NOK 5 mill	
3	Annan fraværskade eller skade med alternativt arbeid		Arbeidsrelatert sykdom som medfører kortvarig eller bergrenset alternativt arbeid		1m³ -100m³		Svart > 1m³ Rød > 10m³ Gul > 100m³		0,1 – 1.0 kg/s		Lokalt område eksponert		Truer lokalt område på innretning		Innbrudd, Skadeverk, Tyveri, Bestikkelser NOK 500 000		Produksjon stans mer en 3 dager		NOK 3 mill	
4	Medisinsk behandling		Arbeidsrelatert sykdom som medfører behandling fra autorisert helsepersonell		0,1m³ -1m³		Svart > 0,1m³ Rød > 1m³ Gul > 10m³		Mindre enn 0,1 kg/s		Liten fare for innretning		Liten fare for innretning		Innbrudd, Skadeverk, Tyveri, Bestikkelser NOK 250 000		Produksjon stans mer en 2 dager		NOK 2 mill	
5	Førstehjelp		Annen arbeidsrelatert sykdom		Mindre enn 0,1 m³		Svart < 0,1m³ Rød 0,01 - 1m³ Gul 0,1 - 10m³ Grønn > 10m³		Vesentlig mindre enn 0,1 kg/s		Ubetydelig fare for innretning		Ubetydelig fare for innretning		Innbrudd, Skadeverk, Tyveri, Bestikkelser NOK 100 000		Produksjon stans mer en 1 dager		Nok 1 mill	

Appendix 1B Risk matrix

The checked item for the highest possible damage in the categorisation matrix can be transferred to the risk matrix for the classification of the incident's severity in the red, yellow or green area. A numerical value (risk factor) is also set for each incident.

The risk factor and/or the incident's "colour" can be decisive in determining whether the incident shall be investigated, and at what task level. The company can use the severity directly from the categorisation matrix or from the risk matrix as the basis for the investigation.

Consequences and probability must also be considered in a criticality assessment (risk assessment) of the incident. This additional uncertainty should be discussed when setting the final severity of the incident and deciding whether the incident shall be investigated or not.



RISK ASSESSMENT MATRIX (RAM)

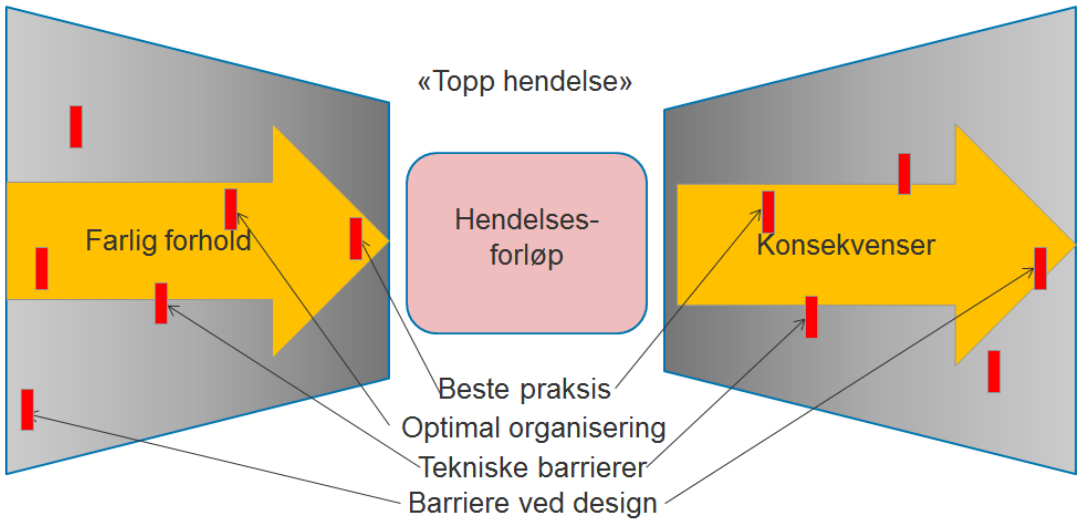
Severity	CONSEQUENCES				INCREASING LIKELIHOOD				
	People	Assets	Environment	Reputation	A Never heard of in the industry	B Heard of in the industry	C Has occured in UI Europe or more than once per year in the industry	D Has happened at the Location or more than once per year in UI Europe	E Has happened more than once per year at the Location
0	No injury or health effect	No damage	No effect	No impact					
1	Slight injury or health effect	Slight damage	Slight effect	Slight impact					
2	Minor injury or health effect	Minor damage	Minor effect	Minor impact					
3	Major injury or health effect	Moderate damage	Moderate effect	Moderate impact					
4	PTD or up to 3 fatalities	Major damage	Major effect	Major impact					
5	More than 3 fatalities	Massive damage	Massive effect	Massive impact					

Appendix 1C Consider "slightly different circumstances"

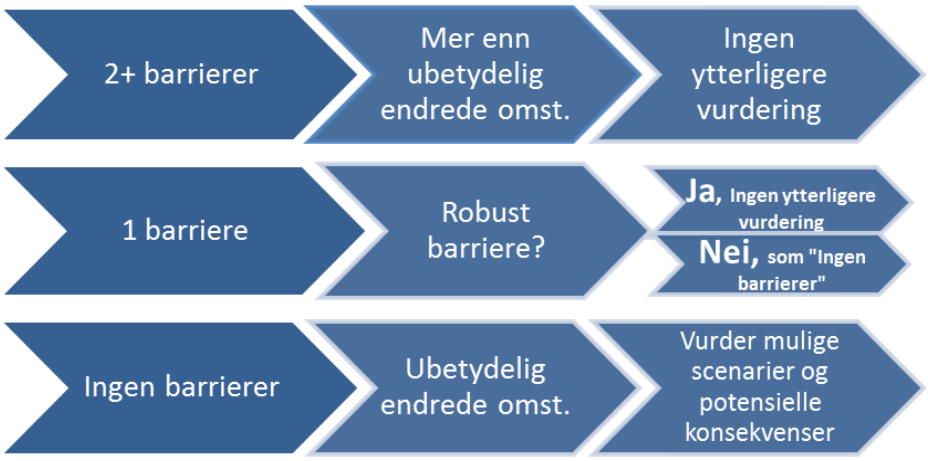
When determining the severity of an incident, matrices are used as described above. Based on the severity of the incident, an assessment of whether the incident shall be investigated must be carried out. When considering an incident's severity, what might have happened under slightly different circumstances (potential consequences) must be analysed. Here, one should consider the possibility that the incident at a given point in the course of events may have taken a different direction than that which actually happened, and whether the consequences could then have been much more serious. For example, could a pressure build up have resulted in another flange/valve springing a leak, and how great is the probability that this could have occurred? If another valve sprang a leak, which barriers would be present? If the incident had gone in a different direction, would this have resulted in more serious consequences?

The three following steps, with figures that illustrate the incident and barrier chain, may be useful when investigating an incident's severity.

1. Identify and assess the effectiveness of existing barriers that may prevent or reduce the consequences.



2. Consider possible scenarios and potential outcomes/consequences if barriers fail or are missing.



3. Does the potential severity from alternative scenarios harmonise with knowledge, experience and common sense?

Organisations that identify and react to weak hazard signals are often referred to as “High reliability organisations (HRO)”. By establishing good practice relating to the analysis of other possible directions in an incident, it is possible to contribute to the characterisation of the organisation as an HRO.

HROs are described as having the following characteristics (Weick & Sutcliffe, 2001):

- Preoccupied with failure
- Sensitivity to operations
- Reluctance to simplify
- Deference to expertise
- Commitment to resilience

Appendix 2 Establishing the investigation team – Mandate

Appendix 2A: Checklist for investigating team competence

Role	Competency requirement	check
Investigation leader	Should have competence (ref. Appendix 2c) and experience in the investigation of incidents. Able to provide professional guidance to the rest of the team that he/she shall lead. Be familiar with the processes and organisational conditions that shall be surveyed or investigated. The investigation leader should have integrity and the trust of the involved parties.	
Method specialist	This person shall have training and experience with the investigation of incidents, the tool that shall be used and knowledge of the relevant procedures for inquiries and investigations.	
Specialist(s)	Specialist(s) shall be experts within the field(s) to which the incident relates. General training within the investigation of incidents, so that the individual is aware of the basic principles, is an advantage but not a requirement.	
Human Factors Specialist	A HF analysis[4] can be important to understand underlaying factors that may influence humans and their work	
Safety delegate	The representative(s) shall help to ensure that the employees' interests are satisfactorily safeguarded with regard to the inquiry or investigation. Participant(s) from the safety team should have training in the investigation of incidents equivalent to that outlined in the course plan in Appendix 2c.	
Suppliers/Sub-suppliers	Representatives from suppliers/sub-suppliers should be included in the team if this is considered useful and relevant. It is presumed that the representative has good knowledge of the conditions relating to the supplier/sub-supplier in the incident.	
Local expertise	For international investigations one should consider adding personnel with knowledge about local conditions, culture, regulations etc.	
Legal Advisor	Companies may select to appoint a legal advisor to support the team. The extent of the advice should be clarified for each case.	

Tasks
The investigation leader has the following tasks (in addition to what is given in the mandate):

- Gather and lead the investigation team based on the mandate given by the client
- Ensure that biased/impartial persons in the team are replaced
- Release the incident area in the event of internal inquiries or investigations
- Continually inform the client of findings that give rise to immediate measures
- Communicate with the client and involved units

Appendix 2 B Mandate

Mandate for the investigation of …… , [Incident – dd.mm.yyyy]

Background: Short description of incident:

In accordance with the company's requirements, an investigation team is appointed in order to:

- Map the course of events leading up to the incident and background to the causal relationship
- Identify immediate and underlying causes
- Identify any deviations from governing documentation
- Identify failed or missing barriers, as well as barriers that have functioned
- Assess reporting and contingency conditions
- Assess the incident's total potential
- Check for similar incidents/conditions and transfer of experience from these
- Give recommendations and suggest measures relating to the incident/conditions
- Suggest and communicate lessons learned
- Any other tasks

The main purpose of this investigation subsequent to the incident is to contribute to learning in order to prevent recurrence and to improve the HSE level.
Including any other purposes .....

The investigation team is comprised of:

- XX, Investigation leader, [Organisation]
- XX, XX, XX [Function in the team], [Organisation]

During the period in which the investigation is on-going, work relating to the investigation will be the investigation team members' first priority. The team members will be available when the investigation work requires this. The client for the investigation is XX

Tentative schedule for the investigation work:

- Draft report for consultation by [dd.mm.yyyy].
- Final report by [dd.mm.yyyy].

_____/_____
Date / XX

Appendix 2c Course plan, investigation of HSE incidents

Working Together for Safety (SfS) has prepared a two-day course plan that course providers can follow to give participants a good theoretical foundation for the investigation of HSE incidents. It is a prerequisite that the participants, who will become investigation leaders, have the personal qualities necessary to lead an investigation.
It is also emphasised that in addition to taking this course, participants should obtain practical experience from taking part in investigations before leading an investigation themselves. Lastly, participants should become familiar with the relevant organisation's internal investigation methodology before leading an investigation – training in methods and tools is NOT a part of this course.

The course plan has the following contents:

Course section	Learning objectives
1 Introduction 0.5 h	Become familiar with the course contents. Get to know the instructors, participants, and safety and security measures at the training site.
2 Regulations and recommendations 1 h	Become familiar with legislation, rules, standards and guidelines/recommendations.
3 The investigation process 1 h	Have knowledge of the various phases of an investigation.
4 Initiation 1 h	Have knowledge of general criteria and requirements regarding the initiation of an investigation. Understand the hierarchy and who decides to initiate an investigation. Have knowledge of the client's role.
5 Start-up and execution 3 h	Have knowledge of the contents of the start-up meeting. Have knowledge of the Petroleum Safety Authority's (PTIL's) role in connection with investigations. Have knowledge of the Petroleum Safety Authority's coordination responsibility in relation to other supervisory bodies (the Climate and Pollution Agency, Coastal Administration, Directorate for Civil Protection, etc.). Collection of data and evidence – understand what kind of data can be relevant to the investigation. Understand who should be interviewed and how the interviews shall be carried out. Summary before leaving the location. Summary day 1 – have a good overview of the day's learning objectives.
6 Survey chain of events 1.5 h	Understand the methodology involved in establishing the chain of events leading up to the incident. Be able to obtain an overview of the chain of events.
7. Causes, nonconformities and barriers 2.5 h	Understand the difference between triggering and underlying causes and be able to identify these. Be familiar with MTO methodology. Be able to assess the need for immediate transfer of experience. Be able to set up a systematic overview of the various causes. Understand the concept of barriers, and how nonconformities are identified. Understand how to observe which barriers have functioned correctly and which have not, and what barriers should be established. Be able to set up barrier analyses and find measures that address causes / breaches of barriers. Be able to utilise all elements in this chapter about the connections between causes, nonconformities and barriers.

8. Summary and report writing 1.5 h	Be able to set up / structure a report. Handling of important factual information that is discovered, but not directly related to the incident itself. Handling of dissent. Have knowledge of further handling and approval of the report. Signatures – know who should sign.
9. Follow-up, transfer of experience and conclusion 0.5 h	Be able to present the report and suggest actions relating to follow-up, communication and transfer of experience. Conclusion/summary of the course.

Appendix 3 Checklist – Start-up and planning

Activity:	check
Check that the Mandate is signed and the checklist in Appendix 2A has been reviewed.	
Clarify who is the owner / contact person at the incident location.	
Clarify securing the area and any criteria for resuming work with the incident owner.	
Clarify any need for the immediate securing of evidence (photographs and video from the incident site, alarm lists, info from computer systems (e.g. process logs), etc. Also check that other conditions such as lighting, weather, spills/discharge/stains etc. are documented.	
Agree work premises for the investigation team.	
Establish a list of involved personnel.	
Consider using written witness statements, ref. Appendix 4B – Witness observation.	
Book travel arrangements / transport to the relevant location.	
Check travel requirements (safety courses, dispensations, etc.).	
Clarify use of technical aids (laptop, camera, etc.) and obtain necessary permissions regarding use and transport.	
Ensure necessary personal protective equipment / work clothes are available for the investigation team.	

Appendix 4 Interview

An investigation seeks to find the probable course of events that led to an incident which happened in the past. Interviews play a central role in an investigation, and if there are people who were involved in the incident, whether directly or indirectly, it is natural to thoroughly interview these individuals. There must be doubt as to the impartiality of the investigators.

The investigator cannot take it as a given that witnesses provide correct, neutral and accurate descriptions of the incident in question. Memory can be unpredictable and is influenced by a number of factors, so **it is important to undertake the interviews as soon as possible after the incident.** One's own processing of the incident affects the experience of it, as does how close or traumatic the incident was for the witness. Interactions and discussions with others can also distort the picture of what actually happened, and false mental reconstructions may interfere with the truth.

Memory can be divided into two parts – short-term memory and long-term memory. Impressions that continue to be a part of the moment and which we are still focused on are stored in our short-term memory. As an impression "matures", the information that is experienced as useless or insignificant is pared away and we forget exponentially (ref Ebbinghaus memory curve). It is therefore a simplified version of an incident that is stored in a person's long-term memory. Another phenomenon worth mentioning is the fundamental attribution error. This describes how we may ascribe memories an erroneous origin, and therefore place them in the wrong context. Statements from witnesses alone should therefore never be used to draw conclusions.

The investigator must also be aware of his/her role as a recipient of information, and not use his/her bias to seek confirmation for the statements given by witnesses. In many ways, it is true that we find that which we are looking for. The interview should therefore be well-planned and prepared for, and the interviewer should strive to maintain an objective stance throughout. The "tone" of the interview will also affect the results. This can include all kinds of factors such as placement, attitude, posture and location to how the interviewer presents him/herself. It is therefore important to establish a good framework for the interview so that the witness feels comfortable. As an example, the interview could be held at the workplace of the person to be interviewed and he could have a safety delegate or a union representative supporting him.

If relevant, the investigation team and interviewer should clarify how they shall manage and relate to the information that is entered on the "Witness observation form", ref. Appendix 4B – Witness observation.

Asking neutral and open questions starting with what, how and why is important to avoid "putting words in the informant's mouth". Closed and leading questions often lead to incorrect answers. How the interview is conducted is a deciding factor in how correct the information received by the investigators will be.

The following steps can be used to ensure a good interview (PEACE-method):

- **P**lanning: All interviews must be thoroughly prepared. What questions need to be answered?
- **E**xplain: The interviewee is received in a friendly manner, and a good relationship is established before the interview commences. The interviewee is informed of the purpose of the investigation.
- **A**ccount: Allow the interviewee to recount his/her version of events without interruptions. More specific questions are then asked, to which the other members of the investigation team contribute.
- **C**losure: The interview shall be concluded with a positive tone, and the option for further interviews or contact is kept open.
- **E**valuate: The interview shall be evaluated so that the investigation team gains a common understanding of the information that has been obtained.

Regardless of the method that is selected, it is important to allow the interviewee to start by providing a free account of the incident in his/her own words. At least two persons from the investigation team should participate in the interviews. All interviews shall be carried out professionally and objectively, and the investigators shall act in a calm and considerate manner.

Interview plan: Especially in an offshore situation it is important to plan the interviews to ensure that the time fits with shift schedules, travels home etc.

Name	Role in incident	Contact location, tel. no., etc.	Homeward journey	Planning of interview	
				Priority/order	Interview time

Appendix 4B Form for witness observation

This form shall be given to those who have, or are expected to have, direct information about the incident that shall be investigated. The form has therefore been handed out to you and other equivalent persons.

The purpose of this form is to enable you to describe what you have observed as soon as possible after the incident. Detailed witness observations are extremely important in order to obtain an understanding of what happened and therefore learn from the incident. Experience shows that important details are often forgotten or unconsciously influenced by others. It is therefore important that the form is completed as soon as possible.

The form will only be used as a support for yourself and the investigation team during the interview process and will be destroyed after the interview.

Before you start to fill out the form, briefly think through what YOU have seen, heard and experienced.

1. Personal data

- Name:
- Occupation/position:
- Employer:
- E-mail address:
- Telephone number:

2. Describe the incident – what did you experience before, during and after the incident?

3. Answer the following questions to the best of your ability (to the extent that they have not already been answered above):

- What were you doing just prior to the incident, and where were you when the incident occurred?
- Did you notice any unusual sounds, smells, vibrations, or anything else?
- Who was present when the incident occurred?
- Where did you go after the incident?
- What did you communicate just prior to, during and after the incident?
- Do you have any other information that may be relevant?

4. If relevant, draw a sketch

Appendix 5 Templates for a good investigation

Appendix 5A Action log
Appendix 5B Time log
Appendix 5C Investigation log
Appendix 5D Investigation report

Appendix 5A Action log

Action no.	Description of action/task	Responsible party	Deadline	Status	Comments

Appendix 5B Time log

Time	Event	Facts/reference	Comments/questions

Appendix 5C Investigation log

INVESTIGATION LOG		
Investigation name		
Report number/ID		
Client (name/org.)		
Client's representative		
Contact person in investigated unit		
Legal advisor		
Investigated unit(s)		
Accident location		
Time of accident	dd.mm.yyyy (hh:mm)	
Investigation team (name)	**Organisation unit**	**Function/role**
		Investigation leader
ASSIGNMENT		
Assignment received and accepted by leader of team	dd.mm.yyyy	
Mandate received	dd.mm.yyyy	*document*
Investigation team established	dd.mm.yyyy (all members in place)	
Agreed changes to assignment	dd.mm.yyyy	
WBS account		
EXECUTION		
Start-up meeting held	dd.mm.yyyy	
Investigation plan established	dd.mm.yyyy	
Start-up, field work	dd.mm.yyyy (data collection, interviews, etc.)	
Status reporting to client *(meetings, presentation, status, etc.)*	Report 1: dd.mm.yyyy Report 2: dd.mm.yyyy Etc.	
Any immediate measures	dd.mm.yyyy	*document*
Summary meeting with investigated unit	Meeting 1: dd.mm.yyyy Meeting 2: dd.mm.yyyy, Etc.	
Deliveries to the investigation *(HFAT, explosion calculations, completed tests, etc.)*	Delivery 1: dd.mm.yyyy Delivery 2: dd.mm.yyyy Etc.	
Debrief completed	dd.mm.yyyy	
QUALITY ASSURANCE		
Quality assurance MTO	dd.mm.yyyy (~3 weeks prior to consultation)	
Quality assurance, causal map	dd.mm.yyyy (~2 weeks prior to consultation)	
Quality assurance report	dd.mm.yyyy (~1 week prior to consultation)	
REPORTING		
Draft for consultation sent	dd.mm.yyyy	
Comments processed	dd.mm.yyyy	
Client offered review of comments obtained via consultation	dd.mm.yyyy	
Report approved by inv. team	dd.mm.yyyy	
Final report sent	dd.mm.yyyy	
Presentations sent	dd.mm.yyyy	
Report released	dd.mm.yyyy	

Released report sent to Petroleum Safety Authority	dd.mm.yyyy	

Appendix 5D Investigation report

Summary: A short summary of the incident, causes and any of the most important recommendations

Incident: A short description of the incident.

Consequences: A short description of the actual consequences the incident has resulted in and the most serious potential consequences (if any) the incident could have resulted in under slightly different circumstances, as well as the incident's (greatest) severity.

Causes: A short description of the most important immediate and underlying causes that have resulted in the incident.

Measures: A short summary of the suggested measures, preferably connected to causes.

English summary: An English translation of the summary.

Mandate for the investigation: The original mandate should be entered here. Any changes to the mandate should also be described in this chapter. This chapter should also contain details of the participants of the investigation team and the client.

Investigation work: A short description of the investigation work that has been carried out and what this has covered.

Background information: An introductory description of relevant conditions, so that the reader is better able to understand the subsequent chapters of the report. Sub-chapters will vary depending on what the incident concerns, such as: System description, Work operation, Work site, Organisation, Responsibilities etc..

Incident: The course of events leading up to the incident which is described below covers the chain of events and facts associated with the attached MTO course of events. Description of the course of events as stated in the MTO diagram.

Similar incidents: Describe similar incidents, with reference to the RUI nos., and the extent to which experience has been transferred from these.

Consequences: Based on the categorisation and classification matrix, the actual and potential consequences are considered for the relevant consequence columns given in this figure.

Actual consequences: Based on the categorisation and classification matrix, state the actual consequences of the incident. Should be structured using a sub-chapter for each actual consequence.

Potential consequences: The investigation team has considered this incident's potential, based on what could have happened under slightly different circumstances.

In order words, it is only down to chance that the potential outcomes of the incident have not occurred.

Based on the categorisation and classification matrix, state the potential consequences that the incident may have had under slightly different circumstances. Should be structured using a sub-chapter for each potential consequence.

Classification of the incident: Classification of severity in accordance with the company's classification system.

Immediate causes: Description of immediate causes. An immediate cause is defined as an unfortunate/hazardous action or condition which triggered one or more individual incidents. See also the MTO course of events.

Underlying causes: Description of underlying causes. An underlying cause is defined as a condition that resulted in one or more immediate causes occurring. See also the MTO course of events.

Barriers and nonconformities: A barrier is defined as a technical, administrative or organisational measure that could have stopped the course of events.

Breached barriers: The barrier breaches that are mentioned below cover those which have contributed to the incident occurring. I.e. if one or more of these had not occurred, the incident would not have happened.

Missing barriers: Description of the barriers that could have prevented the incident from occurring if they had been present.

Intact barriers: Description of the barriers that have contributed to preventing the incident from having more serious consequences.

Nonconformities: Based on the identified barrier breaches, state which of these are nonconformities and give precise references to requirements. A nonconformity is a failure to comply with a requirement set through the company's governing documentation.

Reporting and emergency preparedness: Description of reporting and emergency preparedness follow-up of the incident, as well as the degree to which this has functioned satisfactorily.

Measures and learning: The measures that are described in this chapter are recommended with the aim of preventing similar incidents from occurring in the future and contributing to a general improvement of the HSE level. Here, both short-term and long-term measures can be included. An analysis of measures can also be used as the starting point, based on the methodology described in Chapter 9.1 Learning – an alternative method.

Abbreviations and terminology.
References.
Appendices: (MTO diagram and other templates as necessary).

Appendix 6 Some analysis models and methods

MTO analysis

The basis for an MTO analysis is that human, organisational and technical factors shall be given equal focus in the investigation of an accident. The method is based on HPES (Human Performance Enhancement System).
The MTO analysis consists of three parts:

1. Structured analysis using an incident and cause diagram.
2. Change analysis which describes how incidents deviate from previous incidents or usual practice.
3. Barrier analysis which identifies failed or missing technological and administrative barriers.

Before starting the work of setting up an MTO diagram, it can be useful to register the relevant sub-incidents along a timeline in order to establish an overview. The purpose of this is to continuously systematise and structure relevant information and establish a useful foundation upon which to create the MTO diagram.

The MTO diagram can be prepared using brown paper and post-it notes, or PowerPoint or another computer-based tool.

Fault tree analysis

Fault tree analysis is a method of determining the cause of an accident. The fault tree is a graphical model that shows the different combinations of normal incidents, equipment faults, human errors and environmental conditions that may result in an accident (Høyland et al., 1994).

MORT

Management Oversight Risk Tree (MORT) is a systematic method for the planning and execution of a comprehensive accident investigation (Johnson, 1980). Using MORT, investigators are able to identify omissions relating to specific control factors and management system factors. These factors are identified and evaluated in order to find the causal factors of an accident.

SCAT

The International Loss Control Institute (ILCI) developed the Systematic Cause Analysis Technique (SCAT) in order to support occupational accident investigations. The Systematic Cause Analysis Technique is a tool which enables investigators to investigate and evaluate incidents using a SCAT form. The form functions as a checklist or reference in order to ensure that the investigation looks at all aspects of an incident.

STEP

STEP (Sequentially Timed Events Plotting) is an accident investigation method. The STEP method was developed in order to provide a realistic description of the incident, which is not focused on causes and is the same from accident to accident (Øien, 1995). The STEP method consists of two main parts:

1. Graphical presentation of the course of events
2. Identification and assessment of measures

AEB method

The Accident Evolution and Barrier Function (AEB) model is a method for the analysis of incidents and accidents. The method models the development of an accident as a series of interactions between human and technological systems.

The interaction consists of errors, functional faults and failures that may result in an accident. The method forces the investigator to integrate human and technical systems, as well as investigate the accident using flow chart techniques. An important aim of the AEB analysis is to identify defective barrier functions and the reasons that they failed, and to suggest improvements.

STAMP

Systems Theoretic Accident Modelling and Processes (STAMP) was developed by Nancy Leveson, a researcher at Massachusetts Institute of Technology (USA). STAMP is based upon systems theory, and views accidents as a result of dynamic change processes across several system levels.

STAMP is based on the systematic accident model and the fact that accidents are created through the interaction between system components and processes. Leveson has used principles taken from cybernetics and system control (feedback and control). The model is predefined in the sense that it has basic components that are used as a framework to be filled out (Le Coze, 2008).

TRIPOD

Tripod focuses on systematic factors and how management decisions can lead to hazardous conditions at the workplace. Tripod consists of two tools, where Tripod Beta is a systematic tool for the analysis of incidents/accidents.

Tripod Beta 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 and 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.

ACCIMAP

AcciMap is an analysis method which understands accidents as the result of loss of control of physical conditions/energy. The method 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.

TAPROOT

TapRooT is a systematic investigation methodology which aims to find the root cause of problems. The method is used to investigate and solve the underlying causes of everything from technical operational problems to large scale accidents. A main focus of TapRooT is to analyse and understand people's conduct and actions (human factors). TapRooT focuses on identifying the problems that caused the incident. Each problem is analysed in order to identify underlying causes relating to systematic, cultural and organisational factors. Actions and learning measures are developed based on the analysis.

Kelvin TOP-SET

Kelvin TOP-SET focuses on Technology, Organisation, People, Similar events, Environment (surrounding factors) and Time. It is a stepwise process that includes planning, investigation, analysis, establishment of recommendations and reporting. The process encourages an open mindset and the objective collection of information in order to obtain qualitative data for analysis.

The method focuses on a standardised approach and the structure contains around 400 indicators under the TOP-SET headings. This leads the investigators through the analysis in a consistent, detailed and efficient way.