
Safety and Health in European Mining

Malin Shooks | Bo Johansson | Eira Andersson | Joel Lööw

Division of Human Work Science
2014

This project has received funding from the European Union’s Seventh Framework Programme for research, technological development and demonstration under grant agreement no. 280855
Foreword

This report has been produced for the European Union-project I²Mine, specifically for Work Package 6. It is meant to provide the reader with an overview of health and safety statistics and laws regarding mining. It is also meant to serve as a brief introduction to some risk management tool to be used in early project stages.

The majority of the work for this report has been done by Malin Shooks, with the assistance of Professor Bo Johansson and Doctor Eira Andersson. However, Malin Shooks’ employment with Luleå University of Technology ended before the report could be published. Therefore, I took it upon myself get the report published. While, as mentioned above, most work was done by Malin Shooks, corrections, proofreading, formatting etc. has been done by me.

The area of health and safety in mining is a big and complex one. Coupled with the broad scope of the report, it has not been possible to do a detailed review of the current state of the health and safety situation in mining. I hope, however, that the brief overview provided by the report will be of use of the members of the Work Package, as well as any other reader, by providing a substantial glimpse into the subject.

Luleå, October 9, 2014

Joel Lööw
Safety and Health in European Mining
# Table of Content

1. **Introduction** ................................................................................................................. 1

2. **Risk Management Process** .......................................................................................... 3
   2.1 Context and Scope ......................................................................................................... 5
   2.2 Hazard Identification .................................................................................................... 6
   2.3 Risk Analysis ............................................................................................................... 6
       2.3.1 Risk Matrices ......................................................................................................... 7
       2.3.2 Risk Matrix Procedure ......................................................................................... 9
   2.4 Risk Treatment ............................................................................................................ 10
   2.5 Communicate and Consult ......................................................................................... 13
   2.6 Monitor and Review ..................................................................................................... 14
       2.6.1 Hazard Register .................................................................................................... 15
   2.7 Safety Analysis ........................................................................................................... 15
       2.7.1 Safety Analysis Tools .......................................................................................... 19
   2.8 Discussion .................................................................................................................... 28
   2.9 Tools and Documentation ............................................................................................ 29

3. **Laws and Provisions – EU** .......................................................................................... 30
   3.1 EU Framework ............................................................................................................. 30
   3.2 Application of EU Law ................................................................................................. 33
   3.3 Compliance to EU Laws ............................................................................................... 33
       3.3.1 Exemption to EU Laws ........................................................................................ 34
   3.4 Harmonization of Health and Safety Laws in Europe ................................................. 34
   3.5 Discussion ................................................................................................................... 36
   3.6 Tools and Documentation ............................................................................................ 37

4. **Safety and Health Laws and Provision in EU** ............................................................. 38
   4.1 Treaty on Health and Safety in EU .............................................................................. 38
       4.1.1 Article 153 of the Treaty on the Functioning of the European Union .................. 38
4.2 Safety and Health Directives ................................................................. 39
  4.2.1 Framework Directive 89/391/EEC ............................................. 39
  4.2.2 Daughter Directives .................................................................. 40
4.3 Mining Specific Directives ................................................................. 44
4.4 Laws and Provisions – EU Countries ................................................ 44
4.5 Discussion ....................................................................................... 45
4.6 Tools and Documentation ................................................................. 45

5. Laws and Provisions in Sweden .......................................................... 46
  5.1 EU and Sweden ............................................................................. 46
  5.2 Implementation of EU Directive in Sweden ................................... 48
  5.3 Safety and Health Laws and Regulations – Sweden .................. 49
    5.3.1 SFS 1977 The Swedish Work Environment Act .................. 49
    5.3.2 The Swedish Work Environment Ordinance ...................... 50
    5.3.3 Regulations ........................................................................ 50
    5.3.4 The Swedish Minerals Act 1991:45 .................................. 52
  5.4 Discussion ..................................................................................... 53
  5.5 Tools and Documentation ............................................................... 53

  6.1 Global Regulations ....................................................................... 53
    6.1.1 ISO .................................................................................... 55
    6.1.2 OHSAS 18000 .................................................................. 56
  6.2 Discussion ..................................................................................... 57
  6.3 Tools and Documentation ............................................................... 57

7. Compliance .......................................................................................... 58
  7.1 Compliance and Sanctions ............................................................. 58
  7.2 Health and Safety Inspection .......................................................... 60
  7.3 Discussion ..................................................................................... 61
  7.4 Tools and Documentations ............................................................. 62
8. Incident Statistics .......................................................................................... 63
  8.1 Different Measurements and Indicators .............................................. 63
    8.1.1 Leading Indicators ........................................................................ 63
    8.1.2 Lagging Indicators ........................................................................ 63
    8.1.3 Personal and Process Safety Indicators .................................... 64
    8.1.4 Coincident Indicators ................................................................. 64
    8.1.5 Differences between Leading and Lagging Indicators .............. 65
  8.2 Health and Safety Indicators ................................................................. 66
  8.3 Statistics – EU ...................................................................................... 68
    8.3.1 Regulation on Statistics on Accidents at Work (1338/2008) ...... 68
    8.3.2 Implementing Regulation (349/2011) ......................................... 68
  8.4 Discussion ............................................................................................. 69
  8.5 Tools and Documentation ...................................................................... 70

9. Incident Statistics – EU ............................................................................. 71
  9.1 Resources for Data and Publications ................................................ 71
    9.1.1 European Injury Data Base (IDB) .............................................. 71
    9.1.2 World Health Organisation (WHO) .......................................... 71
    9.1.3 Eurostat ..................................................................................... 71
  9.2 Work Related Health Problems ............................................................. 72
  9.3 Exposure to Risk Factors at Work ........................................................ 73
  9.4 Accidental Injuries at Work ................................................................. 74
  9.5 Fatalities ................................................................................................ 75
  9.6 Discussion ............................................................................................. 76
  9.7 Tools and Documentation ...................................................................... 77

10. Incident Statistics – Sweden ................................................................... 78
  10.1 Near Misses ........................................................................................ 78
  10.2 Workplace Accidents .......................................................................... 79
List of Figures

Figure 2.1: Time/safety influence curve (Szymberski, 1997). ............... 3
Figure 2.2: Contribution of risk assessment to the risk management process (IEC, 2009). ........................................ 4
Figure 2.3: Example of a Risk Matrix with risk ranking (Harms-Ringdahl, 2013). ........................................................ 7
Figure 2.4: Risk assessment matrix ("Risk Assessment Matrix - Bringing it to Life”, 2013). .............................................. 8
Figure 2.5: Procedure for applying Risk Matrix methodology (Harms-Ringdahl, 2013). .................................................. 10
Figure 2.6: Hierarchy of control (based on Safe Work Australia, 2011a). ................................................................. 12
Figure 2.7: Steps controlling OHS hazards and risks (WorkSafe Victoria, 2007). ......................................................... 14
Figure 2.8: Separate methods covering different areas (Harms-Ringdahl, 2013). ......................................................... 20
Figure 2.9: Preliminary Hazard Analysis example ("Preliminary Hazard Analysis”, 2009). .............................................. 22
Figure 2.10: Example of a "What-If" analysis form........................................ 23
Figure 2.11: Example of a HAZOP study ("Hazard & Operability Analysis (HAZOP)”, 2013). ........................................ 25
Figure 2.12: Example of a FMEA template ("Failure Modes and Effects Analysis (FMEA)” , 2004). ............................... 26
Figure 2.13: Example of a FTA (IEC, 2009). ................................................. 27
Figure 3.1: Structure of EU health and safety law. ......................... 31
Figure 3.2: Application of EU Law ......................................................... 33
Figure 5.1: Relationship between EU directives, Swedish legislation and harmonized standards (Bohgard et al., 2009). ................................................................. 47
Figure 5.2: EU directive implementation process ........................................ 49
Figure 6.1: ILO strategic objective and goals (“Mission and objectives”, 2014). ................................................................. 54
Figure 7.1: Swedish Work Environment Authority inspection process. .................................................................................. 61
Figure 9.1: Work-related health problems (European Commission, 2010). .............................................................................. 72
Figure 9.2: Occurrence of one or more work-related health problems in the past 12 months (European Commission, 2010). .............................................................................. 73
Figure 9.3: Exposure at work (European Commission, 2010). .......... 74
Figure 9.4: Accidental injuries in the EU (European Commission, 2010). .................................................................................... 75
Figure 9.5: Fatal and serious accident at work by economic activity (“Fatal and serious accidents at work by economic activity”, 2012). .............................................................................. 76
Figure 10.1: Comparison frequency rate occupational accident and near misses 2009-2012 (GRAMKO, 2013). ....................... 79
Figure 10.2: Reported work accidents per 1000 worker by sector at department level, 2012 – cases with at least one day of absence from work; workers and self-employed (Arbetsmiljöverket, 2013, translation added). ................................................................................ 80
Figure 10.3: Workplace accidents during 1981-2013 in the Swedish mining and mineral industry – all employees, above and underground (Ahl, 2013). ......................... 81
Figure 10.4: Occupational accidents lost day injury frequency rate 2002-2012, Swedish mining and mineral industry, all employees (GRAMKO, 2013). ................................. 82
Figure 10.5: Occupational diseases 2010-2012 (GRAMKO, 2013). ............................................................................................... 84
Figure 10.6: Number of fatalities in Swedish mining and mineral industry, not including contractors (Elgstrand & Vingård, 2013). ................................................................. 86
Figure 11.1: Non-standardised occupational fatal injury incidence rates by industry and total working population for 9 countries averaged over the period 2005-2008 (Lilley et al., 2013)............................... 89

Figure 11.2: Number of fatal accidents at work in mineral - extracting industries and incidence rate per 100,000 workers (Ural & Demirkol, 2008)...................... 90

Figure 11.3: Fatal injury trends by injury prevention domain (1998-2010, 1998 = 100%) in the EU-27 (EuroSafe, 2013)............................................................... 92

Figure 11.4: Death from all mining accidents in China and U.S. (“Lack of Regulation”, 2014). ........................................ 93

Figure 11.5: Fatality rate U.S (Elgstrand & Vingård, 2013). ............ 93

Figure 11.6: Fatal injury frequency rate Australia (Elgstrand & Vingård, 2013). ................................................................. 94

Figure 11.7: Fatality rates in India (Dhoot & Dasgupta, 2013)......... 94

Figure 11.8: Rate of fatal work accidents per 100,000 workers per annum in Brazil (Elgstrand & Vingård, 2013). .......... 95

Figure 11.9: Fatality rates in India (“Facts and Figures 2012”, 2012)................................................................................ 95

Figure 11.10: Number of fatalities in Swedish mining and mineral industry, not including contractors (Elgstrand & Vingård, 2013). ......................................................... 96

Figure 11.11: Fatal occupational accidents in Russian arctic regions compared to Russia (1980 2009) per 100,000 workers (Dudarev, Karnachev, & Odland, 2013). ................................................................. 96

Figure 12.1: The iceberg theory (Mine Safety and Health Program Technical Staff, 2011).................................................. 100

Figure 12.2: Distribution of cost categories of accidents at work and work-related ill-health to individuals (European Commission, 2011). .................................................. 101

Figure 12.3: Hidden costs leading to reduction of net benefits (European Commission, 2011)................................. 102
Figure 12.4: Cost of occupational injuries in the mining industry by economic agent Quebec, 2005-2007 (Lebeau et al., 2013). ...................................................... 104

Figure 12.5: Cost of occupational injuries in the mining industry by cost component, Quebec, 2005-2007 (Lebeau et al., 2013). ...................................................... 105

Figure 12.6: Cost associated with occupational injuries in one year in the mining industry, Quebec, 2005-2007 (Lebeau et al., 2013). ...................................................... 106

Figure 12.7: Correlation between competitiveness and the incidence of accidents at work (ILO, 2006). ...................... 107
List of Tables

Table 2.1: Classification of types of consequences (adapted from Harms-Ringdahl, 2013). ............................................ 9

Table 2.2: Table of projects according to type of measure (adapted from European Commission, 2011). ................. 13

Table 2.3: Safety analysis tools in different stages of the engineering process. .......................................................... 16

Table 3.1: Description of acts. .................................................. 32

Table 4.1: Health and safety framework daughter directives. ........ 41

Table 5.1: Description of EU’s power in different areas (adapted from “EU:s makt varierar”, 2014). ............. 46

Table 6.1: ILO standards. .......................................................... 55

Table 8.1: Personal and process safety indicators. ......................... 64

Table 8.2: Key differences between the characteristics of leading and lagging indicators (ICMM, 2012). .......... 65

Table 8.3: Statistical indicators of ILO related to safety (adapted from ILO, 2012a). ................................................ 66

Table 10.1: Number of contractor lost day cases (adapted from GRAMKO, 2013). ................................................. 82

Table 10.2: Causes for incidents in the Swedish mining industry (GRAMKO, 2013). ........................................... 83

Table 10.3: Number of fatalities (adapted from GRAMKO, 2013). ................................................................. 85

Table 10.4: Number of Contractor Fatalities (adapted from GRAMKO, 2013). .......................................................... 85

Table 12.1: Consequence of a workplace injury to the victim and its family and friends (adapted from European Commission, 2011). ................................................. 103
1. **Introduction**

The need to provide a safe and healthy workplace is obvious to most companies. Other than ensuring that workers return home to friends and family, safe and healthy, at the end of the day, it also make economic sense to the company and society.

But do today’s mines offer a safe and healthy workplace? Incidents in mines have decreased greatly over the last years and large mining companies are talking about goals such as zero harm. Statistics from Sweden, EU and an internationally level show that safety in mines has improved but also that mining is still dangerous compared to many other economic activities. However, as safety is improving, it is not enough to measure only lagging (after the fact) indicators, such as injuries and fatalities. Events leading to incidents must also be detected to prevent injuries from happening.

So, if mining today is still unsafe, how do we improve and ensure a safe and healthy workplace and plan for this in the early stages of mine design? One obvious factor is to adhere to the international and national safety and health laws and regulations. Then, there are also the international standards that companies can adhere to. The fact is that, even though these laws and regulations exist, some mining companies still do not comply with them.

Companies in countries that have extensive laws and regulations, and that adhere to them, have incidents, so what can be done then? One method for continuously identifying, eliminating or reducing risks is the risk management process. This should be done throughout the mining lifecycle but the biggest opportunity to influence these risks is in the early design phase of a project.

To answer the questions and expand on the reasoning, presented above, this report has been produced. The first section of this report will discuss how to design for safety using safety analysis; one of the main safety tools used both in international and national legislations. The next section will review
the legal framework of EU. This might seem unnecessary as the national health and safety laws incorporate EU laws. The reason an overview of EU laws and legislations are still provided is to show how EU law influences national law. Section five and six will explain the legal framework for Sweden and globally followed by a discussion on compliance to these laws. Incident statistics for EU, Sweden and nationally and different measures will be presented in section nine to twelve. The last section will discuss the cost of injuries, both the direct and indirect costs. Each chapter will finish with a discussion on the text just presented. All chapters will also contain a section on tools and documentation. This will list some of the available tools and links to documents.
2. Risk Management Process

There are many hazards in the mining sector that pose a risk to the health and wellbeing of the workers. Some common ones are mechanical hazards, chemical and biological hazards, sources of energy, body stressing or impact hazards, gravity, and psychological hazards. These hazards will, if resulting in workplace injuries, not only affect the individual (momentary, physical and mental) but also infer great costs on its employer and society.

To identify, eliminate or reduce hazards in the workplace, a continuous process of controlling risks throughout the mining lifecycle is required. However, the opportunity of influencing these risk is greatest in the early design phases of a project (Szymerski, 1997), as shown in Figure 2.1.

![Figure 2.1: Time/safety influence curve (Szymerski, 1997).](image)

Even though this model was developed for construction, the same idea can be applied to mining and safety. The curve visualizes why it is important to put great effort and thoughts into safety in the early phases of design.
The continuous process of controlling risks is often referred to in the literature as the risk management process. The international standard IEC/FDIS 31010 Risk management – Risk assessment techniques (2009) illustrate this process as per Figure 2.2.

![Figure 2.2: Contribution of risk assessment to the risk management process (IEC, 2009).](image)

The illustration of the risk management process in Figure 2.2 also shows how risk assessment – including the elements of risk identification, analysis and evaluation – fits into this process. However, risk assessment is just one of the definitions of these elements. Harms-Ringdahl (2013) provides another definition of these elements as being safety analysis – a procedure for analyzing systems in order to identify and evaluate hazards and safety characteristics. Harms-Ringdahl (2013) definition of safety analysis includes

- identification of risk;
Risk Management Process

- understanding;
- estimate level of risk (included, but not mandatory);
- risk evaluation;
- suggested improvements; and
- accident investigation.

This definition better fit the outcomes of the range of tools designed for risk identification, analysis and evaluation. Examples of these are Preliminary Hazard Analysis (PHA) and Jobs Safety and Environment Analysis (JSEA). The last section in this chapter will explain some of these tools along with their strengths and weaknesses. However, we will start with the first step of the risk management process: establishing the context and scope.

2.1 Context and Scope

Establishing the context involves determining and agreeing on the risk assessment objectives and the risk criteria. The risk criteria is often defined by the organization and specified in the risk matrix.

At this early stage it is also important to consider the external and internal parameters that must be taken into account when managing risks. Examples of external parameters are social, regulatory, legislative, culture and competitive while internal parameters includes the structure, roles and capabilities.

Another key element at this stage is to define for what level the safety analysis process will be applied for. At early stages of the work, such as in the design phase, the level is usually defined as in the project level – that is, it defines the project in broad terms. As the project continues, hazards are defined for smaller and more specific areas.

In the operating or exploitation phase of a mine, the hazards can be monitored at a task level. In the design phase, this is seldom possible as it is difficult to know exactly how the tasks will be carried out. However, it is pos-
sible to know the job and its subsequent tasks in broader terms, such as the operating of a machine.

The smaller the boundaries and the more details and knowledge there is about the system, process or tasks, the more detailed the hazard identification will be.

2.2 Hazard Identification

The next step in the process is to identify the hazards. This includes identifying all situations in the workplace that have the potential to cause damage or injury to a person, the environmental, property or equipment. This is an important step in the management of safety as hazards that are not identified cannot be eliminated or controlled.

As has been mentioned earlier in this report, the use of safety analysis tools is good for a systematic process of identifying hazards. Some other ways of identifying hazards are through accident or incidents reports, statistics and workplace inspection. These are all methods that can be used in already established mines with a workplace history.

2.3 Risk Analysis

The risk analysis provides a measure of the risk, making it apparent if the risk must be reduced or if it is at an acceptable level. It also helps focus the attention on managing the significant risks with high likelihood of occurrence and large potential impact.

There are different approaches for evaluating risk, such as comparing systems, relevance judgment and risk matrices – the last having obtained great popularity in many areas. Risk matrices are regarded as easy-to-use and useful and is the predominate approach in technical publications (Harms-Ringdahl, 2013). Subsequently, the following sections will focus on this approach.
2.3.1 Risk Matrices

Risk matrices are often presented as tables with consequences as one variable and probability as the other. For each identified hazard, the probability of it occurring and the consequence becomes the level of risk for that hazard. A simple risk assessment matrix is illustrated in Harms-Ringdahl (2013) guide, as illustrated in Figure 2.3.

<table>
<thead>
<tr>
<th>Probability</th>
<th>Consequence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Minor</td>
</tr>
<tr>
<td>Frequent</td>
<td>Medium</td>
</tr>
<tr>
<td>Probable</td>
<td>Medium</td>
</tr>
<tr>
<td>Remote</td>
<td>Low risk</td>
</tr>
<tr>
<td>Very unlikely</td>
<td>Low risk</td>
</tr>
</tbody>
</table>

Figure 2.3: Example of a Risk Matrix with risk ranking (Harms-Ringdahl, 2013).

An example of a more advanced risk assessment matrix is the one used by the Energy Institute. This matrix includes and defines the consequence on people, assets and the environment. The matrix is presented in Figure 2.4.

Most of the risk matrices also include an area where the risk is too high for a particular task to be carried out. In conducting risk assessments, some people intentionally or unintentionally try to avoid assigning hazard a risk level this high and therefore do not rate it correctly.

Harms-Ringdahl (2013) observed that evaluators sometimes instinctively assume that large consequences related intrinsically to low probabilities. This is not the case and can be dangerous in situations where a large consequence is probable.
Figure 2.4: Risk assessment matrix ("Risk Assessment Matrix - Bringing it to Life", 2013)
In the article *What’s Wrong with Risk Matrices?*, Cox (2008) discusses that, even though risk matrices are widely accepted and used, little research has gone into to validating their performance in improving risk management decision. Cox continues with pointing out the limitations of risk matrices and concludes that they should be used with caution, and only with careful explanations of embedded judgments (Cox, 2008).

By using the term safety analysis, it is almost self-explanatory that that safety is to be analyzed and assessed. However, when a safety analysis is carried out, organizations often consider the consequence to the environment, production, and property (as is shown in Figure 2.4). The classification of consequences can be found in Harms-Ringdahl’s (2013) guide and is presented in Table 2.1.

**Table 2.1:** Classification of types of consequences (adapted from Harms-Ringdahl, 2013).

<table>
<thead>
<tr>
<th>Type of consequence</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety</td>
<td>Injuries to people in accidents.</td>
</tr>
<tr>
<td>Health</td>
<td>Health problems for people.</td>
</tr>
<tr>
<td>Environment</td>
<td>Environmental problems.</td>
</tr>
<tr>
<td>Production &amp; Property</td>
<td>Problems with production, quality, etc., and loss of property.</td>
</tr>
</tbody>
</table>

**2.3.2 Risk Matrix Procedure**

The risk matrix is generally considered a simple tool. However, for its results to be consistent and comparable, considerations must be taken on how it is executed. Harms-Ringdahl (2013) presents an illustration on the procedure for applying Risk Matrix methodology, which is shown in Figure 2.5.

This procedure highlights the importance of clearly defining the rules; it takes away personal perceptions and assumptions from the risk assessment
process. For example, probabilities should be defined as a number, e.g. how many times per year something happens.

It is also important to define in what state the consequences and probabilities should be considered. This means defining if we are looking at the probabilities of something happening with current controls in place, or with no controls in place. This decision greatly alters the probability of something happening.

Defining the rules is not difficult, but could result in a lot of uncertainties in the assessment group and deliver a result that might not sufficiently reflect the current state, if not done correctly.

**Figure 2.5:** Procedure for applying Risk Matrix methodology (Harms-Ringdahl, 2013).

### 2.4 Risk Treatment

Directive 89/391 - OSH "Framework Directive" The Directive 89/391 - OSH "Framework Directive" describes the control of risks firstly by substitution, i.e. replacing the dangerous by the non-dangerous or the less dangerous. It
also gives the collective protective measures priority over individual protective measures.

Safe Work Australia (2011a) describes the approach to risk control with the commonly used “hierarchy of control”. As with the EU Framework Directive, it lists measures to deal with health and safety issues at work and the order in which they should be considered.

The hierarchy of control can be visualized in several different ways (e.g. an upside-down triangle). We have chosen to use a more detailed model with three levels of risk control. It is presented in Figure 2.6.

The top priority in risk management is to eliminate the risks as far as reasonably possible. The first level is the most effective measure of control. It involves eliminating the hazard and associated risk. An example of this would be eliminating the risk of fall by performing the work at ground level.

If the first level is not reasonable practicable, risks should be minimized by substituting the hazard with something safer (e.g. replacing solvent-based paints with water-based ones); isolating the hazard from people, i.e. physically separating people from the source of harm by distance or barriers (e.g. installing guard rails around exposed holes in the floor); or using engineering control (e.g. using trolleys to move heavy loads, or setting work rates to reduce fatigue).

The third and last level should only be used as a last resort. It involves the use administrative control, i.e. work methods or procedures that are designed to minimize the exposure to a hazard. Examples of this include the use of warning signs, worker training, or the development of procedures for safe machine operation. The other approach is the use of personal protective equipment (PPE) (e.g. hard hats, gloves and protective eyewear). It is important to note, however, that PPE limits the harmful effects of hazard but only if they are worn and used correctly.
In an assessment conducted by the European Commission (2011), the costs and benefits of prevention measures was compared. The highest benefit cost ratio was found for measures aimed at substitution or avoidance. The lowest values were found for measures such as training and personal protective equipment, as shown in Table 2.2.
Table 2.2: Table of projects according to type of measure (adapted from European Commission, 2011).

<table>
<thead>
<tr>
<th>Measure</th>
<th>%</th>
<th>Profitability Index</th>
<th>Benefit Cost Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Substitution/avoidance</td>
<td>5.4</td>
<td>2.56</td>
<td>1.60</td>
</tr>
<tr>
<td>Organisational measure</td>
<td>10.7</td>
<td>1.74</td>
<td>1.04</td>
</tr>
<tr>
<td>New equipment/auxiliaries</td>
<td>35.7</td>
<td>1.41</td>
<td>1.40</td>
</tr>
<tr>
<td>Workplace adjustment</td>
<td>10.7</td>
<td>1.37</td>
<td>1.22</td>
</tr>
<tr>
<td>Training</td>
<td>28.6</td>
<td>0.95</td>
<td>1.12</td>
</tr>
<tr>
<td>Personal Protective Equipment</td>
<td>8.9</td>
<td>1.05</td>
<td>1.18</td>
</tr>
<tr>
<td>All</td>
<td>100</td>
<td>1.29</td>
<td>1.21</td>
</tr>
</tbody>
</table>

Profitability index is the ratio of payoff to investment of a proposed project and benefit cost ratio is the overall value for money of a project or proposal.

This study shows that measures considered as being the most effective, such as substitution and avoidance, are also more cost-effective (profitable).

2.5 Communicate and Consult

Communicating and consulting is an essential part of risk management. Communication is the sharing of information and viewpoints; it is multidirectional, interactive, respectful and engaging. Consultation ensures that all relevant viewpoints are taken into account.

By involving the right people at the right time, making sure they understand, are involved and contribute to the process, the best outcome of the risk management process will be achieved. WorkSafe Victoria (2007) visualizes the steps in controlling OHS hazards and risks, as per Figure 2.7.

This figure does not only visualize the continuous process of risk management but also emphasizes the importance of consultation with health and safety representatives, employees and others, in controlling occupational,
health and safety hazards and risks in all steps. This is required by law in Australia.

Figure 2.7: Steps controlling OHS hazards and risks (WorkSafe Victoria, 2007).

2.6 Monitor and Review

The risk management process is an on-going and constantly improving process. Workplaces and work tasks changes over time, which is why the safety analysis process continuously has to be carried out to identify any new haz-
ards. Furthermore, the process has to be revisited to ensure that no hazards were overlooked and that the controls put in place are effective.

One commonly used document for recording and reviewing hazards is the Hazard Register.

### 2.6.1 Hazard Register

A Hazard Register is a summarized record of the hazards identified in a business; where the hazards occur, and the tasks, machinery or situations with which they are associated.

To assist planning, budgeting and risk minimizing, the register provides a starting point for maintaining a log of hazards present in the company. The hazard register is also used to transfer information to the next project phase and as a reference tool and checklist for the design engineers during all phases of design.

### 2.7 Safety Analysis

The elements of identifying, analyzing and evaluating hazards are included in Harms-Ringdahl (2013) definition of safety analysis. In a project, safety analysis can be applied at all stages of engineering and is often applied many times with different levels of detail to provide required information for each stage.

Table 2.3 shows a simple representation of when a certain safety analysis tool can be used in the project life cycle as well as its purpose.
Table 2.3: Safety analysis tools in different stages of the engineering process.

<table>
<thead>
<tr>
<th>Project Life Cycle Stages</th>
<th>Safety Analysis Technique</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conceptual</td>
<td>Preliminary Hazard Analysis (PHA) - Initial</td>
<td>Identify hazardous situations and events within concept design.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prioritize hazards for further analysis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify potential significant project HSEC risks.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Develop recommended actions.</td>
</tr>
<tr>
<td></td>
<td>Checklist</td>
<td>Determine compliance to standards and legal framework.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Check that everything has been covered.</td>
</tr>
<tr>
<td>Prefeasibility</td>
<td>PHA - Review</td>
<td>Review for design changes from concept design or develop new PHA.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify and risk-rank how major unit operation will be affected by deviations from normal operations and behaviour.</td>
</tr>
<tr>
<td></td>
<td>What If?</td>
<td>Provides a basis for a risk register.</td>
</tr>
<tr>
<td></td>
<td>Checklist</td>
<td>As above.</td>
</tr>
<tr>
<td>Feasibility</td>
<td>Hazard and Operability Study (HAZOP)</td>
<td>Assess process controls design hazard/risks at progressive percentage complete in conjunction with FMEA and FTA analysis.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Define possible deviations from the expected or intended performance. Generates consequences, controls and control actions.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Identify hazards introduced through human actions.</td>
</tr>
<tr>
<td>Project Life Cycle Stages</td>
<td>Safety Analysis Technique</td>
<td>Purpose</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------</td>
<td>---------</td>
</tr>
<tr>
<td>Feasibility</td>
<td>Failure Mode and Effect Analysis (FMEA)</td>
<td>Identify potential failure of various parts of a system. Estimate the effect of the failure and how to avoid, and/or mitigate the effects of the failures on the system. Assist in selecting design alternatives with high dependability. Identify human error modes and effects.</td>
</tr>
<tr>
<td></td>
<td>Fault Tree Analysis (FTA)</td>
<td>Identify and analyze factors that can contribute to a specified undesired event. Illustrates factors and their logical relationship to the undesired event.</td>
</tr>
<tr>
<td>Execution and Construction</td>
<td>HAZOP</td>
<td>Review feasibility HAZOP.</td>
</tr>
<tr>
<td></td>
<td>Construction Risk Assessment Workshop (CRAW)</td>
<td>CRAW per work package/area/construction type. Identify risks and controls during execution of project (including contractor).</td>
</tr>
<tr>
<td></td>
<td>Job Safety and Environmental Analysis (JSEA)</td>
<td>Identify hazards and controls for tasks. Assess the risks of tasks. Can be used in the development of work procedures</td>
</tr>
<tr>
<td></td>
<td>Stop, Look, Analyze, Manage (SLAM) or Take 5</td>
<td>Identify hazard and control methods for tasks. Used by individuals.</td>
</tr>
</tbody>
</table>
Table 2.3: Continued.

<table>
<thead>
<tr>
<th>Project Life Cycle Stages</th>
<th>Safety Analysis Technique</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Execution and Construction</td>
<td>Authority to Work (ATW) Process</td>
<td>Ensure all hazards and risks have been assessed and taken into account prior to starting a specific activity.</td>
</tr>
<tr>
<td></td>
<td>Checklist</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>Failure Mode and Effect Analysis (FMEA)</td>
<td>As above.</td>
</tr>
<tr>
<td>Commissioning and Ramp-Up</td>
<td>CRAW</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>WRAC Based Risk Assessment</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>JSEA</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>SLAM or Take 5</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>HAZOP</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>SLAM or Take 5</td>
<td>As above.</td>
</tr>
<tr>
<td>Operation</td>
<td>JSA</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>Checklist</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>FTA</td>
<td>As above.</td>
</tr>
<tr>
<td></td>
<td>JSEA</td>
<td>As above.</td>
</tr>
</tbody>
</table>

Safety analysis can be used in the feasibility stage, to decide whether to proceed with a design or not. When there are several options available, safety analysis can assist in choosing the safest one. During the execution and construction phase, safety analysis can help ensuring that system risks are tolerable. In the operation stage, safety analysis can provide information if work tasks are conducted within an acceptable risk. This information can be used to create safe work instructions. A safety analysis must be reviewed and updated as the project continues. The documents produced are “living” documents that must be updated as the environment and tasks changes.
2.7.1 Safety Analysis Tools

As shown in Table 2.3, there are many safety analysis tools that can be used in the different project stages. Different tools serve different purposes or are more applicable for a certain situation. The preferred tool depends on a number of variables. Some of these variables examples are

- the objective of the study;
- availability of resources (people, time and budget);
- what the business is doing;
- regulatory and contractual requirements;
- in what stage of the business life cycle the business is in; and
- what information is available.

If conducting a thorough analysis, more than one tool can be used to cover more parts of the risk spectrum. Harms-Ringdahl (2003) shows how the three methods of Energy Analysis, Deviation Analysis and Function Analysis identified roughly the same number of hazards, but only 5% were generated by all three methods (refer to Figure 2.8)

This highlights how the different safety analysis tools provide different outcomes and the need to use a number of different tools to cover all areas of safety. It also show that it is important to be familiar with a number of tools in order to choose and use the one that best fits the need of the organization at any particular time and situation.
Figure 2.8: Separate methods covering different areas (Harms-Ringdahl, 2013).

The following sections will describe the tools most suited to the prefeasibility, feasibility and conceptual phase of a project as specified in Table 2.3, namely:

- Preliminary Hazard Analysis (PHA);
- Checklists;
- “What If” Analysis;
- Hazard and Operability Study (HAZOP);
- Failure Modes and Effects Analysis (FMEA); and
- Fault Tree Analysis (FTA).

However, the above is only a recommendation. Many organizations already have a documented risk management process including defined safety analysis tools.


### 2.7.1.1 Preliminary Hazard Analysis (PHA)

The PHA is a tool that can be used in the conceptual design and preliminary design of a project. It is a broad risk ranking approach which main purpose is to identify unwanted events that need to be further investigated.

Figure 2.9 shows a part of a PHA conducted for BHP Billiton for a coal seam operation in Bulli, Australia. The figures under likelihood and consequence are chosen from the definitions in the risk matrix. These two combined provides the risk score. This score then dictates whether it is considered to be within an acceptable risk or if the hazard has to be eliminated or the risk reduced.

A PHA can be used when there is limited information. This makes it a good tool when considering risks early in the design phase. However, the PHA only provides preliminary information and cannot prescribe how risks best can be prevented (IEC, 2009).
### Bulli Seam Operations Hazard Identification Table

<table>
<thead>
<tr>
<th>Project Component</th>
<th>Incident Type</th>
<th>Scenario</th>
<th>Proposed Treatment Measures</th>
<th>Likelihood</th>
<th>Consequence</th>
<th>Risk</th>
</tr>
</thead>
</table>
- Environmental Incident Response Plan.  
- Emergency Control Measures/Procedures and Structure.  
- Surface Transport Management Plan.  
- Public Road Management Plan.  
- Emergency Response (Internal and external emergency response agencies).  
- Manifest of all hazardous materials on-board, Material Safety Data Sheet (MSDS)/Substance Evaluation Form.  
- Operator training (Including Safe Work Procedures).  
- Licensed contractors in accordance with Australian Standards and New South Wales (NSW) legislation.  
- Communications (mobile telephone and radio).  
- Spill response equipment and training.  
- Contractor Incident Investigation. | C | 5 | 22 (L) |
2.7.1.2 Checklists

Checklists are useful to assure nothing has been neglected or missed. They can also be used to determine compliance to standards and ensure consistency. A hazard checklist can be used at any stage of the life cycle of a product, process or system.

There are many free checklists available on the web. These can be used as a starting point but usually need to be adjusted to applicable legislations, directives or standards, as well as to the organization using them.

The strength of this method is that it can be used by non-experts and helps ensure common problems are not forgotten.

On the other hand, a weakness of a hazard checklist is that it does not encourage looking at the situation from different angels and identifying new hazards. Checklists also tend to be visual checks so problems that cannot be observed are often missed (IEC, 2009).

2.7.1.3 “What If” Analysis

In a “What–If” hazard analysis, a team with knowledge of the analyzed area is put together. They then get asked a set of pre-prepared and customized “what if”-questions on potential deviations and disturbances to the facility. For every answer the likelihood and severity is determined and recommendations are made on how to prevent or reduce the risk. The “What If” analysis can be used at any stage of the product, process or systems lifecycle. An example of a form used in a “What If” Analysis is provided in Figure 2.10.

<table>
<thead>
<tr>
<th>What If?</th>
<th>Answer</th>
<th>Likelihood</th>
<th>Severity</th>
<th>Recommendations</th>
</tr>
</thead>
</table>

Figure 2.10: Example of a "What-If" analysis form.
The method is not as detailed as a Hazard and Operability Study (HAZOP), but it has the advantage of being able to identifying hazards associated with interactions between sections of the plant more than other methods. Another advantage of the method is that it requires minimal preparation by the team and it is relatively quick. It also identifies the hazards and risks quickly. With little effort, a risk register and risk treatment plan can be created from the analysis.

The questions are usually made by experienced personnel which could also be a disadvantage as it does not encourage the participants to look into other scenarios other than the one stated in the questions. Another disadvantage is that it is a broad tool; it might not reveal complex, detailed or correlated causes (IEC, 2009).

2.7.1.4 Hazard and Operability Study (HAZOP)

Hazard and Operability Analysis (HAZOP) is a structured and systematic technique for identifying potential hazards and operational problems. The whole system is assessed by systematically questioning how each part can deviate from the intention of the design and then determine if the deviations will increase the hazards. Figure 2.11 show an example of a HAZOP recording template, including example entries.

The method can be used at the design stage by using documents such as Pipe and Instrument Drawings (P&ID), layout drawings and outline operating procedures.

The HAZOP process covers both safety and operational aspects and it generates solutions and risk treatment actions. It is applicable to a range of systems, processes and procedures, and it allows for consideration to the causes and consequences of human errors.

On the downside, the process is very time consuming and thus expensive as it focuses on detailed issues of design. This can also be negative in that it takes the view away from wider or external problems (IEC, 2009).
### Example of a HAZOP study ("Hazard & Operability Analysis"")

**Figure 2.11**: Example of a HAZOP study ("Hazard & Operability Analysis"), 2013.

<table>
<thead>
<tr>
<th>Trigger</th>
<th>Action</th>
<th>Cause</th>
<th>Effect</th>
<th>Control</th>
<th>Review</th>
<th>Frequency</th>
<th>Probability</th>
<th>Consequence</th>
<th>Preventive Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incorrect design</td>
<td>Action</td>
<td>No guard</td>
<td>No guard</td>
<td>Fail</td>
<td>No guard</td>
<td>Daily</td>
<td>High</td>
<td>Major</td>
<td>No guard</td>
</tr>
</tbody>
</table>

**Examples from Cleaning Agent Developments that were used to explain HAZOP Guide Words**

- Required action: a unique guide word that the reader uses to turn his mind to the expected outcome of the activity.
- Description: the action/decision that the reader is to take.
- Command: the action that the reader is to perform.
- Reason: the reason for requiring the action.
- Severe: the impact of requiring the action.
- Value of the action: the value of the action.
- Required action: the action that the reader is to take.
- Description: the action/decision that the reader is to take.
- Command: the action that the reader is to perform.
- Reason: the reason for requiring the action.
- Severe: the impact of requiring the action.
- Value of the action: the value of the action.
2.7.1.5 Failure Modes and Effects Analysis (FMEA)

Failure Modes and Effects Analysis (FMEA) is a systematic method for evaluating a process to identify all possible failures in a design, a manufacturing or assembly process, or a product of service.

Failures are prioritized according to the severity of the consequences, frequency, and how easily they can be detected (see Figure 2.12).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Figure 2.12:** Example of a FMEA template ("Failure Modes and Effects Analysis (FMEA)", 2004).

The FMEA technique breaks down the overall system into a set of sub-systems, then a set of smaller sub-systems and continues that way down to component level. Failures of all system and component are then analyzed.

The analysis can be used in all phases of a process or product, design, redesign and periodically throughout the life of the process, product or service.

The technique is most often used for complex item of mechanical or electrical equipment with a number of sub-systems and components.

One of the strengths of this method is that, if used early in the process, problems can be identified early which leads to reduced cost for equipment modifications in service.

However, the method can only be used to identify single failure modes, not a combination of failure modes. The study can also be time consuming and costly if not managed correctly (IEC, 2009).
2.7.1.6 **Fault Tree Analysis (FTA)**

A Fault Tree Analysis (FTA) is a tool that starts from a single fault at the top of a flow chart and expands out and downward to identify the contributing causes to the single top fault. That is, it starts with an incident and works backwards to hazards. The causes are investigated by asking how the event could have happened. These events are then considered “and” gates or “or” gates (see Figure 2.13).

![Fault Tree Analysis Diagram](image)

**Figure 2.13:** Example of a FTA (IEC, 2009).

The FTA analysis can be carried further by establishing or assigning probabilities of occurrence for each of the faults and undeveloped events. This is called a quantitative fault tree.
The FTA can be used in the design phase of a system to find potential causes of failure and, in turn, assist in the selections of different design options. It can also be used in the operating phase to identify how major failures might occur.

The strength of this analysis is that it is systematic but at the same time flexible. Because of the way it is visualized it provides easy understanding of the system behavior and the factors included.

A weakness of the analysis is that it is time consuming. Therefore it is often used for a small number of incidents. The analysis is not practical for a large, complex facility. It is, however, useful for highly critical or high consequence incidents. Another weakness is that FTA is a static model, i.e. time interdependencies are not addressed. It also only deals with binary states (failed/not failed) (IEC, 2009).

2.8 Discussion

The largest scope to influence a project is in the conceptual and preliminary design phase. It is therefore important to start the risk management process, using safety analysis tools, at this stage.

The safety analysis tools should not only be used to assess and improve in already developed workplaces but also to predict and eliminate risks in future designs.

The risk matric is sometimes used as part of a safety analysis. It is a popular tool for risk assessment but must be used with caution. Assumptions and facts should be explained up front and, to get the best result, the assessment should be done as a team.

Using a safety analysis tool provides a systematic method for identifying and evaluating risks. However, the output of the discussed safety analysis tools are based on the knowledge and the “fairness” of the people involved in the analysis. To ensure the best assessment of the system, it is important
that the group consists of people with broad knowledge of the systems, such as operators, maintainers, managers and safety and health representatives. If there is not enough knowledge about the system among the participants taking part in the analysis, the potential for deviation of the designed functionality or the hazards associated with the work will not be identified.

There are several different safety analysis tools available that can be used for risk identification and assessment. However, it is important to know these methods well enough to be able to choose the one that will provide the required outcome using available resources. For the early design phase of a mine, the preliminary hazard analysis is a recommended tool.

2.9 Tools and Documentation

Checklists are useful for checking compliance against standards. Some examples of available checklists can be found at the links below:

- Mining and Quarry Contractor Safety Checklists (8166)

- Checklists for inspecting the workplace

- State Fund Checklists
  http://www.statefundca.com/safety/HazardChecklists.asp
3. **Laws and Provisions – EU**

Decisions made on laws and provisions in European Union (EU) affects the law in the member state as EU law takes precedence over national law. So, in order to understand national law, there first has to be an understanding of EU laws.

In addition, by understanding how the EU health and safety laws have developed until today, it is easier to understand how safety and health laws will evolve in the future.

These are the reasons for the following sections on EU laws and application, compliance of these laws, and the health and safety harmonization in EU.

### 3.1 EU Framework

The EU work by means of law, i.e. fundamental values, like freedom and equality, are translated into reality by law in the EU treaty.

The highest binding agreement between the EU member states is the EU treaty. The treaty is approved voluntarily and democratically by all EU member countries. As members of the EU, countries give up parts of the authority to rule their nation which will instead fall under the treaty.

The intentions specified in the EU treaty are realized by five types of acts, called regulations, directives, decisions, recommendations and opinions (see Figure 3.1).

The acts can be binding or not and apply to all EU countries or just some. To help the implementation of the directives a set of guidelines are usually developed by EU.
Figure 3.1: Structure of EU health and safety law.
The different acts under the treaty are explained further in Table 3.1.

Table 3.1: Description of acts.

<table>
<thead>
<tr>
<th>Acts</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regulations</td>
<td>A regulation have binding legal force throughout every member of EU as soon it is has been passed.</td>
</tr>
<tr>
<td>Directives</td>
<td>A directive is also legally binding for all members of EU. It is different from a regulation, which is adopted in its entirety, in that a directive instead set out goals that all EU members must achieve. The member states then adopt their national laws to meet the goals set in the directives in any way they decide to. Directives allow for uniformity of union law but also for diversity of national traditions and structures.</td>
</tr>
<tr>
<td>Decisions</td>
<td>A decision is similar to a regulation but is only binding for those it addresses (e.g. an EU country or an individual company). These persons/countries/companies/etc. must be named in the decision and they are the only ones that are bound by it.</td>
</tr>
<tr>
<td>Recommendations</td>
<td>A recommendation is not binding and has no legal power. It is used by institutions to make their views known and suggest actions.</td>
</tr>
<tr>
<td>Opinions</td>
<td>An opinion is a non-binding statement by the institutions.</td>
</tr>
</tbody>
</table>

Regulations, directives and decisions enter into force on the date specified in them. If there is no date specified, they enter into force on the 20th day following the publication.
3.2 Application of EU Law

EU member states answer both to their national laws and to EU laws, as illustrated in Figure 3.2.

Under the treaty, the member states cede part of their sovereignty to the EU. This means that the EU law take precedence over the national law. Members either adopts acts in their entirety, like regulations, or incorporated the EU laws into national law as visualised in Figure 3.2.


3.3 Compliance to EU Laws

The European Commission is responsible of ensuring all EU members follow the EU law. The Secretariat-General helps the Commission by ensuring member states incorporate EU law into their national law. They are also required to take action when members do not do this. The Commission can take EU members to the Court of Justice if they fail to comply.
An example of how this process can work is the Swedish Confederation of Professional Employees (TCO) reporting Sweden to the European Commission in 2007. The argument was that that Swedish rules for workers on fixed term contracts were in breach of EU’s Fixed-Term Work Directive 1999/70/EC. The EU-Commission asked the Swedish Government questions, who in turn found the allegation unjustified. The EU-Commission did not agree and launched an infringement procedure.

In 2013, TCO reported Sweden to the European Commission again. Sweden must now fully implement Directive 1999/70/EC and notify the Commission of the measures taken. If this is not done, the Commission may decide to refer Sweden to the European Court of Justice.

If the EU member does not comply when brought before the Court of Justice, the member might have to pay a fine. An example of this is the Environment Commissioner suggestion of a daily penalty of €14,912 a day for Sweden’s failure to license industrial installation that is operating without permits. This would stand each day after the Court ruling until Sweden complies with the judgment.

### 3.3.1 Exemption to EU Laws

EU member can negotiate to be exempt from certain regulations if there are specific reasons. An example of this is Sweden’s exemption from the EU ban of tobacco for oral use (snus) – not including smoking or chewing. In Sweden, 20 percent of males and 4 percent of women uses snus daily (Statens folkhälsoinstitut, 2011). When Sweden entered EU in 1995, it was granted a permanent exemption of this ban.

### 3.4 Harmonization of Health and Safety Laws in Europe

Improving health and safety at work has been a major concern of the EU authorities since the 1980's. With people and products increasingly moving across borders, the need for harmonization of health and safety rules has increased. Cross country projects, e.g. the Öresund Bridge between Den-
mark and Sweden, also increase the need for common health and safety rules.

There are also several businesses objectives for harmonizing work health and safety regulations in the EU. Firstly, a harmonized health and safety law would reduce the compliance costs for multi-national businesses. If the requirements are the same in different countries, the cost to achieve compliance when establishing in a new country would be lower as it would be the same as where they are already established. Secondly, it would make the reviewing of compliance easier for regulatory agencies that work in several countries. Thirdly, if less time is taken up to achieve compliance, businesses should have more time to improve safety outcomes.

Even though there have been improvements in the area, there are still differences between member states. An example of this is the penalties for non-compliance of safety and health laws, which can vary from €55 and €819,780 depending on the legislation in that member state and the seriousness of the violation (Vega & Robert, 2013).

Australia has also been working on harmonizing health and safety laws. They had the problem of different laws in different States, Territories and the Commonwealth. This meant that businesses that operated in several States and Territories had to learn different sets of rules for different states and territories. The same went for the workers that moved between states; they had to learn different rules depending on where they worked.

In 2008, Australia agreed that a model Act and Model Regulations would be developed, which each jurisdiction would seek to enact, to get more consistent laws across Australia. On the first of January 2012, the harmonized Work Health and Safety (WHS) legislation came into effect in New South Wales, Queensland, the Australian Capital Territory, the Commonwealth and the Northern Territory. The harmonized WHS laws in South Australia and Tasmania came into effect on 1 January 2013. Victoria and Western Australia are yet to agree to sign up to the harmonized legislation.
In Europe, the need for harmonized health and safety has pushed the main focus of development of new health and safety regulations to EU instead of individual member states.

### 3.5 Discussion

As people and products travels across border more frequently, the need for a harmonized health and safety law has increased. EU directives are a way of harmonizing the law within EU while, at the same time, letting member states keep their national traditions and structures.

As compliance with health and safety laws and regulations gets less complicated for businesses to understand and achieve, more time and efforts can be spent working on improving safety. However, it is important that businesses keep striving to improve their safety beyond the goals set in the directives and national legislations to reach the goal of zero harm. It is also important to keep a process of continuous improvement and learning from best practices.

To find out the effects of the harmonization in Australia, an interview with a regional manager of health and safety for Australia-Asia was conducted. The manager found one positive effect to be that the same language is now used throughout the different states. He also found the training of people becoming easier as the same rules applies to all employees. Finally, he mentioned that the harmonization has made it easier for companies working across states due to the common compliance.

At first, the manager did not see any negative effects of the harmonization of health and safety rules and regulations in Australia. This is in line with the literature review, where negative effects of the harmonization were not widely discussed. The only comment the safety manager made during the interview was the initial extra workload on businesses in understanding what had changed and the required training to familiarize everyone with the new legislation.
3.6 Tools and Documentation

European law is explained on the European Union webpage
http://europa.eu/eu-law/index_en.htm
4. Safety and Health Laws and Provision in EU

EU authority has been working on improving health and safety at work since the 1980’s. In the single European Act of 1986, health and safety was first introduced in the treaty. It was also during this decade that the Framework Directive 89/391/EEC on improving the protection of workers with regard to accidents at work and occupational diseases was published. This directive has since then formed the basis for 28 health and safety “daughter directives”.

The following sections will explain the EU health and safety laws and provisions in more detail and provide links to relevant directives.

4.1 Treaty on Health and Safety in EU

Three treaties had been taken into action before Health and Safety at Work was introduced for the first time. This was done in the European Economic Community treaty with the adoption of the Single European Act in 1986, in article 118A.

In 1997, the Amsterdam treaty incorporated article 118A into article 137 of the treaty. The article came to have legal power and affected of the treaty of Nice in 2001. The Lisbon treaty came into effect in 2007. For more information on the treaties, refer to the European Union home page: http://europa.eu/eu-law/treaties/index_en.htm

4.1.1 Article 153 of the Treaty on the Functioning of the European Union

Article 153 of the treaty on the Functioning of the European Union sets out the objectives and rules for health and safety in EU and starts as follows:

1. With a view to achieving the objectives of Article 151, the Union shall support and complement the activities of the Member States in the following fields:

(a) improvement in particular of the working environment to protect workers’ health and safety;
(b) working conditions;
(c) social security and social protection of workers;
(d) protection of workers where their employment contract is terminated;
(e) the information and consultation of workers; EN C 326/114 Official Journal of the European Union 26.10.2012
(f) representation and collective defence of the interests of workers and employers, including co-determination, subject to paragraph 5;
(g) conditions of employment for third-country nationals legally residing in Union territory;
(h) the integration of persons excluded from the labour market, without prejudice to Article 166;
(i) equality between men and women with regard to labour market opportunities and treatment at work;
(j) the combating of social exclusion;
(k) the modernisation of social protection systems without prejudice to point (c).


4.2 Safety and Health Directives

Directives set the goals that all EU members must achieve. For the EU, the main health and safety directive is the Framework Directive 89/391/EEC. Currently, this directive forms the basis for 28 “daughter directives”.

4.2.1 Framework Directive 89/391/EEC

The Framework Directive 89/391/EEC is designed to improve the protection of workers with regard to accidents at work and occupational diseases. The directive holds principles on the prevention of risk, the protection of safety and health, the assessment of risks, the elimination of risks and accident
factors, the informing, consultation and balanced participation and training of workers and their representatives.


4.2.2 Daughter Directives
The framework directive forms the basis for 28 “daughter directives” that can be split up into six areas. They are

- workplace, equipment, signs, and personal protective equipment;
- exposure to biological agents;
- sector specific and worker related provisions;
- exposure to chemical agents and chemical safety;
- exposure to physical hazards; and
- provisions on workload, ergonomic and psychosocial risks.

A detailed list of the above mentioned areas and associated directives is presented in Table 4.1.
<table>
<thead>
<tr>
<th>Area</th>
<th>Directive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exposure to biological agents – OHS</td>
<td>Directive 2000/54/EC – On the protection of workers from risks related to exposure to biological agents at work</td>
</tr>
<tr>
<td>directives</td>
<td></td>
</tr>
<tr>
<td>provisions – OHS directives</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Council Directive 92/85/EEC – On the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding</td>
</tr>
<tr>
<td>Area</td>
<td>Directive</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Sector specific and worker related provi-</td>
<td>Council Directive 93/103/EC – Concerning the minimum safety and health</td>
</tr>
<tr>
<td>sions – OHS directives</td>
<td>requirements for work on board fishing vessels</td>
</tr>
<tr>
<td></td>
<td>improving the safety and health protection of workers in the mineral-</td>
</tr>
<tr>
<td></td>
<td>extracting industries through drilling</td>
</tr>
<tr>
<td></td>
<td>for improved medical treatment on board vessels</td>
</tr>
<tr>
<td></td>
<td>Council Directive 92/57/EEC – On the implementation of minimum safety and</td>
</tr>
<tr>
<td>Area</td>
<td>Directive</td>
</tr>
<tr>
<td>-----------------------------------------------------------</td>
<td>---------------------------------------------------------------------------</td>
</tr>
<tr>
<td></td>
<td>Directive 2003/10/EC of the European Parliament and of the Council – On the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise)</td>
</tr>
<tr>
<td></td>
<td>Directive 2002/44/EC of the European Parliament and the Council – On the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibration)</td>
</tr>
<tr>
<td></td>
<td>Council Directive 96/29/Euratom – Basic safety standards for the protection of the health of workers and the general public against the dangers arising from ionizing radiation</td>
</tr>
<tr>
<td></td>
<td>Council Directive 90/269/EEC – On the minimum health and safety requirements for the manual handling of loads where there is a risk particularly of back injury to workers</td>
</tr>
</tbody>
</table>
4.3 Mining Specific Directives

Some of the daughter directives are applicable to the mining industry. Among other, these concern on the areas of machine safety, personal protection equipment and pressure equipment.

Two directives that are directly applicable to the mining industry are


4.4 Laws and Provisions – EU Countries

As discussed previously in this chapter, EU directives must be incorporated into national law. To review each EU member state’s occupational health and safety and mining specific laws and regulations refer to the International Labour Organizations (ILO) website where links to applicable national laws are provided: [http://www.ilo.org/dyn/natlex/natlex_browse.details?p_lang=en&p_country= AUT&p_classification=22.02&p_origin=COUNTRY&p_sortby=SORTBY_COUNTRY](http://www.ilo.org/dyn/natlex/natlex_browse.details?p_lang=en&p_country=AUT&p_classification=22.02&p_origin=COUNTRY&p_sortby=SORTBY_COUNTRY).

ILO will be explained further in section 6.1, on international laws and provisions.
4.5 Discussion

Even though only two directives were mentioned as being directly related to mining, many of the non-mining specific directives in safety and health are also applicable. Which of these directives that are applicable depends on, for example, the type of mining conducted and equipment used. As health and safety evolves in EU, new directives are also implemented which might be applicable.

4.6 Tools and Documentation

The European Agency for Health and Safety at Work provides links to all health and safety directives from the following link: https://osha.europa.eu/en/legislation/directives. All directives are sorted under categories so that they are easy to find.

ILO’s website for links to all national laws is also helpful, refer to http://www.ilo.org/dyn/natlex/natlex_browse.details?p_lang=en&p_country=AUT&p_classification=22.02&p_origin=COUNTRY&p_sortby=SORTBY_COUNTRY
5. Laws and Provisions in Sweden

As an example of an EU member state governed by both EU laws and national laws, the following sections will discuss the health and safety laws and provisions in Sweden. It will describe the implementation process of EU laws into Swedish laws and then present Swedish laws related to mining.

5.1 EU and Sweden

As mentioned above, Sweden is directed both by EU law and Swedish national law. However, EU’s influence on national law varies between areas. In some areas like trade, the EU has the full power to implement laws. In other areas, Sweden can create their own laws if there are no existing EU laws in that particular area. An example of the latter is environment and transport. In areas like culture, Sweden makes their own laws while the EU decides on supportive measures like EU-grants. In areas like schooling, housing policies and health care, the EU has no deciding power and it is up to Sweden to decide their own laws. Table 5.1 illustrates EU’s power in different areas and lists some examples.

Table 5.1: Description of EU’s power in different areas (adapted from “EU:s makt varierar”, 2014).

<table>
<thead>
<tr>
<th>Area 1</th>
<th>Area 2</th>
<th>Area 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU has sole power to create laws and make agreements</td>
<td>EU share power with member states</td>
<td>EU can only provide actions to support, coordinate or complement member countries’ actions</td>
</tr>
<tr>
<td>Custom unions, trade policies, and monetary politics for member states with the euro as currency</td>
<td>Inner markets, environment, transport, and areas on freedom, safety and fairness</td>
<td>Industry, culture, tourism, and education</td>
</tr>
</tbody>
</table>

Some examples of these areas are
To make changes or add to the areas that the EU governs or have input on, all member states must agree on the change and the new tasks the EU has been assigned.

An example of how EU directives influence the Swedish work environment legislations and standard is illustrated in the book “Work and technology on human terms” by Bohgard et al. (2009), as shown in Figure 5.1.

Figure 5.1: Relationship between EU directives, Swedish legislation and harmonized standards (Bohgard et al., 2009).
5.2 Implementation of EU Directive in Sweden

Member states like Sweden are responsible for implementing EU directives into national laws and provisions.

For Sweden this process starts with the department who is responsible for the particular area within the Swedish Government Office, looking at how the directive can be implemented in Sweden. If Sweden already have provisions covering the goals set in the EU directive, all Sweden has to do is to notify the EU Commission.

If this is not the case, the Government puts together an investigation group to investigate what measures must be taken and if new laws or provisions are required. This is then presented as “Statens Offentliga Utredningar” (SOU) or a report within the “Departementsserien” (Ds).

For example, EU Directive 2008/104/EC is to ensure good working conditions for temporary agency workers. An inquiry chair in Sweden was tasked with presenting a proposal of how this directive was to be implemented in Swedish national law. The result was presented as a SOU. The result from the inquiry is then sent to the groups or organizations affected by the decision.

The next step is for the Government to present a proposition for a new or changed law to the Swedish Parliament. Once the Parliament has voted for the changed or new law, it is implemented. Once completed, the Government notifies the EU commission. The described process is illustrated in Figure 5.2.
5.3 Safety and Health Laws and Regulations – Sweden

The Work Environment Act is the legal foundation of Swedish work environment. The act is passed by the Swedish Parliament or Riksdag. To support the act and provide more detail, there are regulations. The regulations are developed and issued by the Swedish Work Environment Authority (Arbetarskyddsstyrelsen). The following sections will describe the Swedish health and safety act and the mining related regulations in more detail.

5.3.1 SFS 1977 The Swedish Work Environment Act

The Work Environment Act is a framework law that provides goals for a good working environment. The act applies to practically all areas of occupational life including, among others, students, self-employed persons and inmates in institutions.

The act specifies that the main responsibility of the working environment lay on the employer. The employer is always responsible for their own operations and for preventing work related accidents and ill-health. It is also the employers’ responsibility to ensure that the work is carried out in a satis-
factory work environment. The law especially emphasizes the employer’s responsibility for

- internal control;
- introduction, instruction, training, education;
- job modification and rehabilitation; and
- consideration for the worker’s individual qualifications and conditions.

To review the Swedish Work Environment Act, refer to [http://www.government.se/content/1/c6/10/49/76/72d61639.pdf](http://www.government.se/content/1/c6/10/49/76/72d61639.pdf)

### 5.3.2 The Swedish Work Environment Ordinance

The Swedish Work Environment Act is complemented by the Work Environment Ordinance. The ordinance contains regulations on

- safety representatives,
- safety committees,
- reporting of serious injuries, and
- reporting of serious incidents.

The work environment ordinance also contains a provision for penalty if the employer does not promptly report serious accidents and incidents to the Swedish Work Environment Authority.

To review the Swedish Work Environment Ordinance in Swedish, refer to [http://www.av.se/lagochratt/aml/arbetsmiljoforordningen.aspx](http://www.av.se/lagochratt/aml/arbetsmiljoforordningen.aspx)

### 5.3.3 Regulations

The regulations issued by the Work Environment Authority are collected in the Statue Book. Each regulations starts with AFS, followed by the year, serial number and the name of the regulation.
The sections below will detail the regulations relevant to the health and safety in Swedish mining.

5.3.3.1 **AFS2001:01 Systematic Work Environment Management**

The Systematic Work Environment Management regulation specifies the employer’s requirement to examine, implement, and follow up work environment issues. The objective of the regulation is to prevent any health hazards and accidents at work. It is also written to ensure that employees enjoy a satisfactory working environment.

This regulation translates parts of EU framework directive 89/391/EEC on the employer’s duty, to improve workers health and safety in the workplace. It also expands on and specifies how the employer can fulfill its obligations (chapter three, 2 § in the Work Environment Act).

To read the Systematic Work Environment Management regulation refer to http://www.av.se/dokument/inenglish/legislations/eng0101.pdf

5.3.3.2 **AFS2010:1 Rock and Mining Work**

The objective of the provisions is to prevent ill-health and accidents during rock and mining work. This provision voids the old provision, AFS2003:2 Mining Work.

The Rock and Mining Work regulation translates parts of the Council Directive:

- 92/85/EEC on the introduction of measures to encourage improvements in the safety and health at work of pregnant workers and workers who have recently given birth or are breastfeeding;

- 92/91/EEC concerning the minimum requirements for improving the safety and health protection of workers in the mineral extracting industries through drilling; and
• 92/104/EEC on the minimum requirements for improving the safety and health protection of workers surface and underground mineral extracting industries.

The provision provides a list of requirements for ventilation, vehicles, rock drilling and pregnant and breastfeeding employees, among others.

To read the Rock and Mining Work in Swedish, refer to [http://av.se/dokument/afs/afs2010_01.pdf](http://av.se/dokument/afs/afs2010_01.pdf)

5.3.3.3 **AFS2007:01 Blasting Work**

This regulation contains the requirements for carrying out blasting work. It provides the requirements for handling of explosives, charging work, detonating fuses and evacuation, guarding and initiation, among others.

To read the Blasting Work regulation in Swedish, refer to [http://av.se/dokument/afs/AFS2007_01.pdf](http://av.se/dokument/afs/AFS2007_01.pdf)

5.3.3.4 **AFS 1999:03 Building and Civil Engineering Work**

The Building and Civil Engineering Work regulations translate the following EU regulations on constructions to Swedish law:

• 89/654/EEC Workplace Requirements, and

• 92/57/EEC Temporary or Mobile Construction Sites.

To read the Building and Civil Engineering Work regulation, refer to [http://av.se/dokument/afs/AFS1999_03.pdf](http://av.se/dokument/afs/AFS1999_03.pdf)

5.3.4 **The Swedish Minerals Act 1991:45**

Sweden also has the Mineral Act 1991:45 that applies to a number of different minerals such as gold, silver, iron occurring in the bedrock, and copper.

The Minerals Act regulates the mining industry and governs the procedure for acquiring exploration permits and exploitation commissions on land.
To read the Minerals Act, refer to

5.4 Discussion
The Work Environment Act is the legal foundation of Swedish work environment. It defines the relationships between employer and employee. There are also regulations that support the acts. For mining, there are some specific regulations on rock, mining and blasting work, for example.

As health and safety evolves in the EU and Sweden, new regulations are implemented which might also be applicable.

5.5 Tools and Documentation
For a list of provisions and general recommendations in English, developed by the Swedish Work Environment Authority, refer to http://www.av.se/inenglish/lawandjustice/provisions/.

As we have seen in previous sections, the EU and its members are making progress in establishing, improving and harmonizing their safety and health laws and provisions. However, this raises the questions of what common health and safety requirements there are for countries outside the EU.

The following sections will present the International Labor Organization (ILO) and its health and safety standards that can be ratified by member countries. The section will also describe the international standards of ISO and OHSAS, which organizations can be certified against.

6.1 Global Regulations
The International Labour Organization is the oldest of the Specialized Agencies of the United Nations and has been working together with the European Union since 1958.
ILO’s main aims are to promote rights at work, encourage decent employment opportunities, enhance social protection and strengthen dialogue on work-related issues ("Mission and objectives", 2014).

Its four strategic objectives are to

- promote and realize standards and fundamental principles and rights at work;
- create greater opportunities for women and men to decent employment and income;
- enhance the coverage and effectiveness of social protection for all; and
- strengthen tripartism and social dialogue.

They visualize this strategic objective and goal as per Figure 6.1.

**Figure 6.1:** ILO strategic objective and goals ("Mission and objectives", 2014).
ILO draws up and oversees international labour standards for its member countries. In August 2012, ILO had had 185 member states ("Alphabetical list of ILO member countries", 2013).

The standards set up by ILO are either conventions or recommendations. The two standards are described in Table 6.1.

**Table 6.1: ILO standards.**

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventions</td>
<td>- Legally binding international treaties.</td>
</tr>
<tr>
<td></td>
<td>- Principles to be implemented by ratifying countries.</td>
</tr>
<tr>
<td>Recommendations</td>
<td>- Non-binding guidelines.</td>
</tr>
<tr>
<td></td>
<td>- Can be a related to a convention providing a more detailed guideline on how the convention could be applied.</td>
</tr>
</tbody>
</table>

As well as setting up standards, ILO also helps the member states to ratify and implement them. One such convention for mining is the ILO Safety and Health in Mines Convention of 1995 (No. 176), which was ratified by 28 countries by August 2012.


ILO has also issued other conventions related to mining, such as the Asbestos Convention of 1986 (No. 162), refer to http://www.ilo.org/dyn/normlex/en/f?p=NORMLEXPUB:12100:0::NO:12100:P12100_INSTRUMENT_ID:312307:NO

**6.1.1 ISO**

The International Organization for Standardization (ISO) was founded in 1947 and is the world’s largest developer of voluntary international standards. The organisation is a network of national standard bodies and in 2011
there was 160 countries part of this network. It has since its start published more than 19500 international standards – the two most well-known being ISO 9000 (quality) and ISO 14000 (environment).

ISO standards are presented under the technical committee it belongs to. ISO/TC 82 is the committee for mining. It provides standards for among other areas rock drilling.

In the area of safety there are the following committees ISO/TC 94 Personal Safety – Protective clothing and equipment, ISO/TC 159 Ergonomics and ISO/TC 262 Risk management, among others.

ISO themselves do not certify companies or organizations to ISO standards. Instead, the certification is done by external certification bodies, many of which are private.

**6.1.2 OHSAS 18000**

OHSAS 18000 is an international occupational health and safety management system specification comprising of two parts: 18001 and 18002. OHSAS 18001 specifies requirements for occupational health and safety management systems and its sister standard, OHSAS 18002, provides guidelines for the implementation of OHSAS 18001.

The technical specification was created by various institutions, such as national standards bodies, certification bodies and academic bodies. Furthermore, OHSAS 18001 has been developed to be compatible with the ISO 9001 (Quality) and ISO 14001 (Environmental) management systems standards.

Since the standard was first published in 1999 there have been 16,000 certifications to the standard in over 80 countries ("Health and safety management systems specification OHSAS 18001 is now a British Standard BS OHSAS 18001:2007", 2007). It is mainly applied in countries which lack their own health and safety legislation. When compared to the Swedish
Work Environment Management, AFS 2001:1 (SAM), OHSAS 28001 has more documentation requirements, and is more comprehensive and stringent.

As with ISO, the registration of OHSAS 18000 is done by a third party certification body. The certification body will review documentation to ensure that the company fulfils the OHSAS 18001 requirements, followed up by an audit. Once this is completed, a certificate of registration to OHSAS 18001 is issued. Organisations or businesses are then visited, usually annually, to ensure that the systems are maintained.

6.2 Discussion
What seems to be the major difference between the ILO standards, ISO and OHSAS is that, even though the workers in the end benefit from a safer workplace from all certifications, the ILO marketing is for the benefit of the worker while ISO and OHSAS marketing seems to be more focused on the benefit for the business or organization. The incentive for an ISO or OHSAS certification is the perceived value of safety from other organizations or businesses. Only when safety is considered as real value, will businesses invest time and money to comply with international standards such as ISO and OHSAS.

6.3 Tools and Documentation
ILO’s website for links to all national laws is useful for reviewing laws in different countries, refer to

For a list of all ILO Conventions refer to
7. Compliance

In an anthology by Elgstrand & Vingård (2013), containing a summary of health and safety for 16 countries, the legislation related to mining is summarized as adequate. However, the authors highlight the need to improve on the supervision and control of that legislation. This seems to be a common thought in the literature on health and safety in mining.

The following section will discuss the compliance to mining legislations and sanctions in different countries.

7.1 Compliance and Sanctions

Countries like China, India, Indonesia, Congo and South Africa are among those countries where supervision and control is considered insufficient, according to Elgstrand & Vingård (2013). The anthology mentions two reasons for this, low priority and difficulties in attracting and keeping qualified inspectors.

ILO also found compliance to be an issue during the 100th Session of the International Labour Conference in June 2011. During this conference, the delegates pointed out that labour inspection cannot be fully understood without considering the procedures for imposing sanctions or penalties. ILO followed up on this and in a report by Vega & Robert (2013) on Labour Inspection Sanctions: Law and practice of national labour inspection systems.

Vega & Robert (2013) highlight the fact that many inspection systems around the world lack qualified personnel, investigative tools and workplace data, making it difficult to carry out the labour inspectorate’s enforcement function. For example, Chile, who has about 900 mines, only has 18 inspectors (Gatu, 2010).

Other difficulties facing labour inspectors are budget cuts on social spending, absence of effective systems of sanctions, penalties not being followed
through, and penalties not being adequate leading to companies not caring (Vega & Robert, 2013).

The two main categories of sanctions used are monetary and work stoppage. An example of monetary sanction for health and safety is applied in China, where penalties depend on the level of severity of the incident and the party responsible. The penalty is applied as follows:

- Manager in charge – 30 to 80% of previous year’s earnings.
- Managers within the unit – 1 million to 50 million CNY (about €130,000 to €6,500,000).
- Local authorities or OSH department – Punishments by supervisors and may be criminally prosecuted (Vega & Robert, 2013).

Work stoppage is used by many countries for non-compliance with occupational safety and health provision and includes stopping the operations, closing the establishment or withdrawing an employer’s operating license (Vega & Robert, 2013). An example of this is Australia, where the workplace health and safety representatives in several jurisdictions can “stop work” if the work is not done safely.

There has started to be an increased need to harmonize compliance requirements due to integration processes and movement across borders. Vega & Robert (2013) provide an example of this with the Heads of Workplace Safety Authorities in Australia and New Zealand implementing a number of harmonization initiatives for health and safety issues. Issues were prioritised and a common approach was established.
7.2 Health and Safety Inspection

As an example of how a health and safety work inspection can be carried out, the Swedish inspectorial process of Swedish Work Environment Authority (Arbetsmiljöverket) will be explained in this section.

In Sweden, health and safety inspections are carried out by the Swedish Work Environment Authority. This process starts with the inspector phoning or sending a letter to announce the visit. However, this is not a legislative requirement; the inspector also has the right to turn up unannounced.

One or more inspectors can be present during the visit and the main part of the visit is spent on control. From the visited company, a representative for the staff or the safety representative (skyddsombud) usually participates.

During the visit, the inspector communicates how he or she sees the work environment and any shortcomings. The shortcomings are also documented in an inspection notice (inspektionsmeddelande). The inspection notice is usually sent out about three weeks after the visit. The document describes the shortcomings in the work environment and the employer is encouraged to rectify these shortcomings. The employer must also present how this is done to the Swedish Work Environment Authority.

If the employer does not follow the recommendations in the inspection notice, the Work Environment Authority can prohibit certain actions or activities, as well as order the employer to rectify the shortcomings in the work environment. This prohibition can also include monetary fines. The decision includes a time and place where the employer can appeal the decision. The described process is illustrated in Figure 7.1.
7.3 Discussion

As mentioned in the text, one of the reasons for non-compliance to health and safety laws and regulations are its low priority to businesses and organi-
zations. If an organization or business does not have a mature safety culture, other goals, like production, are considered to be of higher value. To change this, the perceived value of safety must be heightened.

For example, in Sweden, environmental friendly and fair trade product are perceived by the byers as important. This is not the case so much in Australia, where byers are still more focused on the price. However, in Australia, safety has got a high perceived value. An example of this is that large mining companies ask for safety indicators and use them in the evaluation process when assigning work to contractors.

7.4 Tools and Documentations

For more information on inspections in Sweden, refer to http://www.av.se/inenglish/inspections/
8. Incident Statistics

As with all areas where improvements are required or targets are to be met, health and safety must be measured to understand how strategies, processes and activities used by the organization are working. Safety statistics is not just of importance to a business internally, but good safety statistics can, for example, also benefit companies by reducing costs of insurances. In many countries, good safety statistics also weigh heavily in the ability of getting new contracts and can increase the access to external capital.

The following sections will present different types of safety indicators and measurements of safety.

8.1 Different Measurements and Indicators

There are different types of safety indicators – the most commonly discussed being leading indicators (also called activities and before-the-fact indicators) and lagging indicators (also called outcome and after-the-fact indicators). However, some references are also made to personal safety and process safety indicators and coincident indicators.

8.1.1 Leading Indicators

Leading indicators measure the direct precursors to harm. It provides warning before an event, which could lead to an incident, occurs. This means it is of high value as it could prevent loss or damage to people, environment or property. However, leading indicators can be difficult to implement and can often not be used for external benchmarking (ICMM, 2012). Examples of leading indicators are the number of performed Job Safety Analysis (JSA), observations and leadership walk around.

8.1.2 Lagging Indicators

Lagging indicators measure final outcomes. They are tools that identify the hazard once it has manifest. Lagging indicators are most widely reported in the mining industry (Ekevall, Gillespie, & Riege, 2008). These indicators
are generally easy to collect and measure and are required due to regulatory reporting requirements, (ICMM, 2012). Three common indicators are Lost Time Injury Frequency Rates (LTIFR), Fatal Injury Frequency Rates (FIFR) and Disabling Injury Severity Rates (DISR).

### 8.1.3 Personal and Process Safety Indicators

Hopkins (2009) describes personal and process safety indicators in the article “Thinking about process safety indicators”. The two indicators are described in Table 8.1.

<table>
<thead>
<tr>
<th>Standard</th>
<th>Explanation</th>
<th>Examples</th>
</tr>
</thead>
</table>
| Personal Safety Indicator | - Hazards affecting individuals  
- Have little to do with the processing activity of the plant | - Falls  
- Trips  
- Crushing  
- Vehicle accidents |
| Process Safety Indicator  | - Hazards arising from the processing activity in which the plant may be engaged  
- Usually damages the plant or have the potential to damage plant  
- Potential to generate multiple fatalities | - Escape of toxic substances  
- Release of flammable material |

Hopkins (2009) argues that process safety indicators must be chosen to measure the effectiveness of the control upon which the risk control system relies. Whether they are described as leading or lagging does not matter.

### 8.1.4 Coincident Indicators

Coincident indicators measure events at the time they occur, as opposed to leading and lagging indicators which measure future events or events that already have occurred. These indicators are mainly used in the field of economy and will not be discussed further in this report.
8.1.5 **Differences between Leading and Lagging Indicators**

Table 8.2 reflects some key differences between the characteristics of leading and lagging indicators.

Table 8.2: Key differences between the characteristics of leading and lagging indicators (ICMM, 2012).

<table>
<thead>
<tr>
<th>Leading indicators</th>
<th>Lagging indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>are actionable and relevant to objectives</td>
<td>are retrospective</td>
</tr>
<tr>
<td>identify hazards before the fact</td>
<td>identify hazards after the fact</td>
</tr>
<tr>
<td>allow preventative actions before hazards manifests as an incident</td>
<td>require corrective actions to prevent another similar incident</td>
</tr>
<tr>
<td>allow response to changing circumstances through implementing control measures before the incident</td>
<td>indicate that circumstances have changed; control measures can be implemented after the incident</td>
</tr>
<tr>
<td>measure effectiveness of control systems</td>
<td>measure failures of control systems</td>
</tr>
<tr>
<td>measure inputs and conditions</td>
<td>measure outcomes</td>
</tr>
<tr>
<td>direct towards an outcome that we want or away from an outcome that we don’t want</td>
<td>measure the current outcome without influencing it</td>
</tr>
<tr>
<td>give indications of systems conditions</td>
<td>measure system failures</td>
</tr>
<tr>
<td>measure what might go wrong and why</td>
<td>measure what has gone wrong</td>
</tr>
<tr>
<td>provide proactive monitoring of desired state</td>
<td>provide reactive monitoring of undesired effects</td>
</tr>
<tr>
<td>are useful for internal tracking of performance</td>
<td>are useful for external benchmarking</td>
</tr>
<tr>
<td>identify weaknesses through risk control system</td>
<td>identify weaknesses through incidents</td>
</tr>
<tr>
<td>are challenging to identify and measure</td>
<td>are easy to identify and measure</td>
</tr>
<tr>
<td>evolves as organizational needs change</td>
<td>are static</td>
</tr>
</tbody>
</table>
8.2 Health and Safety Indicators

In its manual, Decent Work Indicators Concepts and definitions, ILO (2012) sets out standards for the collection and presentation of statistics of different occupational injuries. Table 8.3 presents lists ILO’s definitions of these measures.

For comparison between countries, fatal occupational injury frequency rate is the most reliable, as it is easy to identify and measure. Many countries have also been legally obligated to report this statistic, which is why the data is readily available for most countries.

Injury statistics are more difficult to compare between countries as they are underreported in many countries. Many countries also lack information concerning working hours, which means injury rates cannot be calculated (Elgstrand & Vingård, 2013). Another difficulty is that different countries also have different approaches to data collection of occupational injuries as well as their definition.

Table 8.3: Statistical indicators of ILO related to safety (adapted from ILO, 2012a).

<table>
<thead>
<tr>
<th>Methods of computation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupational injury frequency rate, fatal</td>
</tr>
<tr>
<td>Fatal occupational injury frequency rate</td>
</tr>
<tr>
<td>Number of new cases of occupational fatalities during the reference period</td>
</tr>
<tr>
<td>Fatal occupational injury incident rate</td>
</tr>
<tr>
<td>Number of new cases of occupational fatalities during the reference period</td>
</tr>
</tbody>
</table>
### Methods of computation

#### Occupational injury frequency rate, non-fatal

- **Non-fatal occupational injury frequency rate**
  \[
  \frac{\text{Number of new cases of non-fatal occupational injury during the reference period}}{\text{Total number of hours worked by workers in the reference group during the reference period}} \times 1,000,000
  \]

- **Non-fatal occupational injury incidence rate**
  \[
  \frac{\text{Number of new cases of non-fatal occupational injury during the reference period}}{\text{Total number of workers in the reference group during the reference period}} \times 100,000
  \]

- **Non-fatal occupational injury severity rate**
  \[
  \frac{\text{Number of days lost due to new cases of non-fatal occupational injury during the reference period}}{\text{Total number of hours worked by workers in the reference group during the reference period}} \times 1,000,000
  \]

#### Time lost due occupational injuries

- **Time lost per occupational injury**
  \[
  \frac{\text{Number of days lost due to new cases of occupational injuries during the reference period}}{\text{Number of occupational injuries during the reference period}}
  \]

#### Labour inspection (Inspectors per 10,000 employed persons)

- **Labour inspection**
  \[
  \frac{\text{Number of labour inspectors}}{\text{Number of employed persons}} \times 10,000
  \]
8.3 Statistics – EU

EU provides regulations on statistics. Two such regulations are statistics on accidents at work (1338/2008) and its implementation regulation (349/2011).

8.3.1 Regulation on Statistics on Accidents at Work (1338/2008)

Article two in this regulation states that member states shall supply to the Commission (Eurostat), statistics on the following domains:

- health status and health determinants,
- health care,
- causes of death,
- accidents at work, and
- occupational diseases and other work-related health problems and illnesses.


8.3.2 Implementing Regulation (349/2011)

Article two in the implementing regulation, state that EU member states must transmit to the Commission (Eurostat), microdata on persons who had an accident in the course of work during the reference period and the associated metadata.

8.4 Discussion

The focus seems to have shifted towards leading indicator as the preferred measures, as some lagging indicators, such as LTIFR and DISR, have two significant limitations: they are sensitive to differences in definitions, and they focus on past performances (Ekevall et al., 2008). To reach goals set up by some of the big mining companies, like BHP’s aspiration of zero harm, incidents must be avoided by identification and avoidance before the fact. However, lagging indicators are also useful when presented in a chart; they can show trends and help in determining, for example, whether the safety management system is improving or not.

The shift from lagging to leading indicators can be compared to the shift in maintenance from corrective to preventative maintenance and the use of condition based maintenance. Condition based maintenance is used where the cost of lost production is very high. Through regular inspection, measuring or continued supervision, the system gives indications of when it is time to change parts or do services or adjustment. This way, situations leading to breakdowns are identified before the fact and can be rectified and, furthermore, breakdowns are fewer which leads to higher production.

The same idea can be practiced in the area of OSH through understanding of what events will lead to safety incidents. If these are then measured and supervised, they can provide indications on if an incident is about to happen, which in turn means that it can be avoided.

The International Council on Mining and Metals (ICMM) has put together a report on the overview of leading indicators for occupational health and safety in mining (2012). In this report, they provide an overview of OHS leading indicators and an approach to implementing these indicators. To review their report, refer to

https://www.icmm.com/leading-indicators
Finally, a comment has to be made about health and safety statistics regarding the mining industry, as the following section will dwell deeper into the subject. While the statistics provided in this report serve their purpose in providing the reader with an overview of the health and safety situation in mining today, they also have shortcomings. The biggest shortcoming is that the statistics, for the most part, include the whole economic activity of mining. This includes underground and open-pit mining, coal and metal mining, and so on. This is problematic because the health and safety situation vary between different kinds of mining (at times, this difference is especially significant, e.g. coal mining compared to non-coal mining). However, as mentioned above, the statistics provided are sufficient enough to give a reader a brief overview of the current health and safety situation in mining.

### 8.5 Tools and Documentation

The European Community Health Indicators (ECHI) Project has specified which indicators should be provided by all EU member states and how this should be done. Data on health and safety for EU can be derived from their homepage using their Heidi data tool, available at [http://ec.europa.eu/health/indicators/echi/](http://ec.europa.eu/health/indicators/echi/)
9. Incident Statistics – EU

Statistics show that mines are still a dangerous workplace compared to other economic activities in the EU. Therefore, even though the safety has improved over the years, there is still work to be done in reducing incidents in mining in the EU further.

This section will show how mining compare to other economic activities in EU in regards to safety. This will be done by presenting data from the Eurostat report, “Health and safety at work in Europe 1999–2007” (European Commission, 2010).

However, the section will start by presenting some of the resources for data and publications on safety in the EU.

9.1 Resources for Data and Publications

This section will present some of the resources available for data and publications on safety and health in the EU. All resources presented are available online.

9.1.1 European Injury Data Base (IDB)

The European Injury Data Base (IDB) is a data source that contains standardised cross-national information on the external causes of injuries treated in selected emergency departments (EDs) in the EU. To view their statistics, refer to http://ec.europa.eu/health/data_collection/databases/idb/

9.1.2 World Health Organisation (WHO)

WHO is the directing and coordinating authority for health within the United Nations. To view their health and safety publications, refer to http://www.who.int/publications/en/

9.1.3 Eurostat

Eurostat is the statistical office of the EU, tasked with providing the EU with statistics at European level. The data enables comparisons between
countries and regions. Anyone can access and search for Eurostat data on their webpage:
http://epp.eurostat.ec.europa.eu/portal/page/portal/eurostat/home

9.2 Work Related Health Problems

Examples of work related health problems include musculoskeletal problems, stress, depression and anxiety. Data show that in 2007, mining and quarrying was the sector with the highest level of work-related health problems, see Figure 9.1.

Figure 9.1: Work-related health problems (European Commission, 2010).

Figure 9.1 shows relative occurrence of work-related health problems among different sectors in EU. Furthermore, Figure 9.2 shows that mining and quarrying is one of the sectors which have seen the biggest increase in work-related health problems.
Incident Statistics – EU

9.3 Exposure to Risk Factors at Work

In the Eurostat report (European Commission, 2010), exposure to risk factors affecting physical health at work included difficult work postures, work movements and handling of heavy loads, risk of an accident, exposure to chemicals, dusts, fumes, smoke or gases, and noise or vibration. Factors including mental well-being are time pressure, overload of work, bullying or harassment, and violence or threat of violence. Figure 9.3 show exposure at work in the past 12 months affecting physical health and mental well-being in different sectors in the EU27 (%) in 2007.
The figure shows that mining and quarrying has the highest exposure at work for factors affecting physical health, while it shows among the lowest exposure among the sectors to factors affecting mental well-being.

### 9.4 Accidental Injuries at Work

The number of workers reporting one or more accidental injuries at work or in the course of work in the past 12 months for mining and quarrying by year (%) is shown in Figure 9.4.
Figure 9.4: Accidental injuries in the EU (European Commission, 2010).

Statistics show that the number of reported injuries at work in mining and quarrying in the EU has reduced by approximately 30% from 1999 to 2007. This is especially large compared to the other sectors.

9.5 Fatalities

The fatal and serious accidents at work for the mining and quarrying industry in EU-27 are shown in Figure 9.5.
The figure shows that mining and quarrying has the seventh highest total number of fatal accidents at work in the EU. Construction had the highest number of fatal accidents with more than one in four (26.1%) of the total fatal accidents in the EU-27.

9.6 Discussion

The Eurostat data (European Commission, 2010) show that while having high exposure at work for factors affecting physical health such as risk of an accident, dusts, noise and vibration miners in Europe have the lowest exposure to factors affecting mental well-being such as time pressure, overload of work and harassment.

EU statistics also show that mining is still a dangerous workplace compared to a lot of other economic activities in terms of accidental injuries. However, the fatalities are lower than construction, which accounts for one in four of the total fatal accidents in the EU-27.
Mining and quarrying is also one of the sectors that show the biggest reduction of accidental incidents from 1999 to 2007.

9.7 Tools and Documentation

In December 2008 Regulation 1338/2008 was adopted by the European Parliament and the Council. This regulation provides information on the health statistics that is required from each EU member state. To review the Regulation refer to

10. Incident Statistics – Sweden

If comparing only the incident statistics for Sweden with other countries, Sweden is doing well. However, when compared to the average risk, both the fatality and injury statistics in mining in Sweden is high. This shows that there are still a lot of room for improvement in the area of health and safety in Swedish mining.

The following sections will present the incident statistics for Sweden using data from The Mining and Mineral Industry Work Environment Committee (GRAMKO) and Swedish Work Environment Authority (Arbetsmiljöverket). The four sections will present data for near misses, incidents, occupational diseases and fatalities in Swedish mining.

The purpose is to show the reader what incidents and injuries occur in Swedish mining today. This is to illustrate that there is still much that can be done to improve on safety by thinking of and designing for safety in the early design phases of a project.

10.1 Near Misses

Near misses are unplanned events that do not result in any injuries, illnesses or damages, but could have done so. The documentation of near misses is important as it can be used for learning and identifying preventative actions to stop a similar event from happening. This in turn will improve the safety.

GRAMKO (2013) reports 2572 near misses in Sweden 2012. This is 190 less reported near misses compared to 2011 (GRAMKO, 2012). As near misses are being a more known and measured indicator, this figure is likely to be a good measure of safety for Swedish mining.

Figure 10.1 compares the frequency rate of occupational accident and near misses from 2009 to 2012.
This figure shows a ratio of approximately one accident to 22 near misses in 2012.

10.2 Workplace Accidents

An incident happening in the course of work, causing physical or mental harm, is defined as a workplace accident. In Sweden 2012, 120 workplace accidents in the economic activity of mineral extraction were reported (Arbetsmiljöverket, 2013). As 8170 people was working in this sector in 2012 (Arbetsmiljöverket, 2013), almost one in 70 workers had a workplace accident. This puts the economic activity of mineral extraction as having the second highest number of reported workplace accidents per 1000 worker in 2012 in Sweden, refer to Figure 10.2.
These numbers highlights the need for improving safety in Swedish mines. Bengt Järvholm states, in the anthology by Elgstrand & Vingård (2013), that the accident rate for employees in the mining industry in Sweden – which in 2010 was 16 per 1000 workers – is high compared to the average Swedish employee with an accident rate of 6 accidents per 1000 worker.

However, there has been a clear trend since the early 1980’s, showing a steep decline in workplace accidents in the mining industry, as shown in Figure 10.3.
As shown in Figure 10.3, there were 51 accidents in 1981 per one million hours worked. In 2011, this figure was 7.7. The trend has slowed down in the last ten years, which can be more clearly seen in Figure 10.4.
For contractors, statistics show an increased trend in accidents causing lost days (Table 10.1). However, it is not clear if this increase is because of more contractors being injured in their work, or is due to contractors have begun reporting incidents to greater extent than before.

Table 10.1: Number of contractor lost day cases (adapted from GRAMKO, 2013).

<table>
<thead>
<tr>
<th></th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of lost day cases</td>
<td>46</td>
<td>58</td>
<td>65</td>
<td>80</td>
</tr>
</tbody>
</table>

Finally, the main reasons for work-related injuries resulting in time of work in minerals extraction sector are presented in Table 10.2.
Incident Statistics – Sweden

Table 10.2: Causes for incidents in the Swedish mining industry (Arbetsmiljöverket, 2013).

<table>
<thead>
<tr>
<th>Cause</th>
<th>Number of incidents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Loss of control</td>
<td>46</td>
</tr>
<tr>
<td>Fall of person</td>
<td>21</td>
</tr>
<tr>
<td>Slide/fall of object</td>
<td>18</td>
</tr>
<tr>
<td>Movement with load</td>
<td>17</td>
</tr>
<tr>
<td>Leakage</td>
<td>5</td>
</tr>
<tr>
<td>Electrical, fire explosion</td>
<td>4</td>
</tr>
<tr>
<td>Violence</td>
<td>1</td>
</tr>
</tbody>
</table>

10.3 Occupational Diseases

An occupational disease is a disease resulting from exposure to risk factors (conditions or substances) arising from a work activity. ILO’s list of occupational diseases includes diseases caused by exposure to agents arising from work activities, diseases by target organ systems and occupational cancer (ILO, 2002). Examples of occupational diseases are diseases caused by copper or its compounds, hearing impairment caused by noise and bronchopulmonary diseases caused by hard-metal dust.

The highest number of occupational diseases reported to the Social Insurance Agency in Sweden, 2012, was musculoskeletal disorders, followed by hearing impairment (see Figure 10.5).

Musculoskeletal pains affect the muscles, bones and joints. The cause can be traumas to an area of the body, falls, sprains, auto accidents, repetitive movements, etc. Musculoskeletal loads in the Swedish mines have changed over the years, from mostly having involved heavy work to, now, involving computer work and steering equipment with joysticks (Elgstrand & Vingård, 2013).
Figure 10.5: Occupational diseases 2010-2012 (GRAMKO, 2013).

The hearing impairment is caused by high noise levels in the mines. The hearing protecting has greatly improved over the years but noise is still a problem in the Swedish mines.

Air pollutants used to be a higher risk in Swedish mines but have reduced since the introduction of forced ventilation. Silicosis also used to be a major risk but is now well controlled and low in traditional mines.

10.4 Occupational Fatalities

An occupational fatality represents a worker killed while at work or performing work related tasks. As there are few occupational fatalities in mining in Sweden, this statistic is not as useful as near misses or injuries used for the purpose of improving workplace safety. However, it is useful for comparison between countries as it is easy to define and usually reported.

The Swedish mining industry has had only three (not including contractors) reported fatalities in the last ten years (2003-2013), as shown in Table 10.3.
Table 10.3: Number of fatalities (adapted from GRAMKO, 2013).

<table>
<thead>
<tr>
<th>Year</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

For contractors, SveMin report three fatalities between 2009 and 2012 (see Table 10.4).

Table 10.4: Number of Contractor Fatalities (adapted from GRAMKO, 2013).

<table>
<thead>
<tr>
<th>Year</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatalities</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

The four fatal accidents in mining and related industries between 2007 and 2010 represent 15 deaths per 100,000 employees and year. This is much higher than the average in Sweden. Therefore, the frequency of fatal accidents is low in number, but high in relative terms compared to the average risk for Swedish workers (Elgstrand & Vingård, 2013).

SveMin (Ahl, 2013) statistics, from 1953 to 2012, show a considerable decrease in the number of fatal accidents, especially between the 1950s and 1980s (Elgstrand & Vingård, 2013), see Figure 10.6.
Figure 10.6: Number of fatalities in Swedish mining and mineral industry, not including contractors (Elgstrand & Vingård, 2013).

The cause of deaths in Swedish mines varies. Two of the deaths were due to an elevator falling down into a shaft. One was due to a mass slide, burying a man after the settling of the mountain. Another, in 2002, occurred when a man hit a rock with a vehicle and was thrown out of it, contracting such serious brain damages that he later passed away.

10.5 Discussion

Injuries and fatalities in mining in Sweden are low in comparison with other countries and, furthermore, the incidents and fatalities in Swedish mining have been steadily decreasing in the last twenty years. However, when compared to other industries within Sweden, it is apparent that improvements can and should be made. As discussed by Elgstrand & Vingård (2013), the risk of a fatal accident in mining is still high compared to the average risk for Swedish workers.

To reduce the workplace incidents, one important task is to get better at measuring leading indicators such as near misses. The increasing number of
reported incidents among contractors could be an indicator that the reporting of incidents is becoming more common in Sweden – at least among contractors. By taking near misses into account in the early project stages, the causes can be investigated and improvements included for the later stages.

The fatality statistics among contractors in Sweden has been higher compared to non-contractors during the last few years (GRAMKO, 2013). An explanation to this could be that contractor’s come in for a short time, constantly transition from place to place, each with a new workplace culture. This leads to the workers not being familiar with some risks and may not always understand them.

Safety in Swedish mines has been and still is a high priority to the large mining companies. However, fatalities are still happening and the incident rate is the second highest among the different economic activities in Sweden. This shows that there is still much work to be done before Swedish mining can reach the goal of zero injuries.

10.6 Tools and Documentation

For GRAMKO’s reports on occupational injuries in Swedish mining and the minerals industry, refer to
http://www.svemin.se/vara-fragar/arbetsmiljo_3_1_1/branschstatistik
11. Fatality Statistics

Every day, more than 40 (at least 15,000 per year) miners die around the world (ILO, 2003). That is close to two workers each hour. And even though mining only accounts for one percent of the global workforce, it is responsible for up to five percent of fatal accidents at work (ILO, 2003). But where are these miners dying? Is the fatality frequency in different countries much the same or does it vary?

This section will compare the fatality statistics for differences countries to identify which countries have the lowest fatality rate in mining. Knowing this, we can learn from these countries and see what tools and method they are using in early mine design, to provide a safer workplace.

We will also look at trends to provide a better understanding of the safety situation in mines; what it used to be, what it is today, and what it likely will be in a few years.

11.1 Comparison

The fatality rates between countries vary greatly. One example is the fatality rate (death per 100,000 workers) for China, which in 2005 was 173.88 for coal mining and washing and 145.98 for non-coal mining (ILO, 2012b). This can be compared with Sweden’s fatality rate, which, between 2007 and 2010, amounted to 15 deaths per 100,000 employees and year (Elgstrand & Vingård, 2013). Furthermore, the number of notified work-related fatalities, between 2009 and 2010, in Australia’s mining industry was 3.5 (Safe Work Australia, 2011b).

A comparison of fatality rates between countries, by industry, over the period 2005-2008, is presented in a report by Lilley, Samaranayaka, & Weiss (2013). The results are summarized in Figure 11.1.
**Figure 11.1:** Non-standardised occupational fatal injury incidence rates by industry and total working population for 9 countries averaged over the period 2005-2008 (Lilley et al., 2013).
Figure 11.1 highlights both the big variance between countries as well as the high fatal injury incidence rate in mining compared to other working populations. The figures show that out of the countries represented in the table, Australia and Norway has the lowest standardised occupational fatal injury incidence rate, while New Zealand has the highest.

Another comparison of countries fatality rates is presented by Ural & Demirkol (2008) in Figure 11.2.

![Figure 11.2: Number of fatal accidents at work in mineral-extracting industries and incidence rate per 100,000 workers (Ural & Demirkol, 2008).](image)

Figure 11.2 shows, that out of the countries represented in the figure, Turkey has the highest fatal incidence rate, while Australia, Germany and Great Britain have the lowest.

Ekevall et al. (2008) refer to the review of safety performance in the global mining industry, by Ural & Demirkol (2008), finding that Australia had one of the lowest mining fatality rates in the world. Between 2009 and 2010, six
people died in mining in Australia. This equals a fatality rate (fatalities per 100,000 workers) of 3.5 for this period (Safe Work Australia, 2011b).

Compared to Australia, South Africa’s safety performance in mining is very poor. To have reached the average performance of Australia by 2013, South Africa’s mining industry would have had to improve by at least 20% per year (Hermanus, 2007). However, the government has worked on improving the working conditions in mining. The number of fatalities in South African mines dropped from 774 in 1984 to 128 in 2010. But the fatality and injury rates are still high in South Africa, especially in underground gold mines.

In Chile, the number of death in mining has decreased annually up until 2000. Since then, the rate has tended to stabilize at around 0.10 per million working-hours. In 2010, 45 deaths were recorded, corresponding to a rate of 0.13 per 1,000,000 (Elgstrand & Vingård, 2013).

11.2 Trends

The number of fatalities in mining overall has declined since the late 1900. The trend in mining follows the trend for overall work fatal injuries in Europe, which also has been declining since the late 1990 (EuroSafe, 2013), see Figure 11.3.

The reduced number of fatalities in mining is largely considered to be due to changed mining technology, such as automation, remote control vehicles and the use of more advanced materials. Increased mechanization and higher safety awareness, including safety legislations and training, are also considered to contribute to the reduced fatalities in mines.
Figure 11.3: Fatal injury trends by injury prevention domain (1998-2010, 1998 = 100%) in the EU-27 (EuroSafe, 2013).
The trend of reduced fatalities in mining can be illustrated by referring to individual countries, as seen in Figure 11.4 through Figure 11.11.

**Figure 11.4:** Death from all mining accidents in China and U.S. ("Lack of Regulation", 2014).

**Figure 11.5:** Fatality rate U.S (Elgstrand & Vingård, 2013).
Figure 11.6: Fatal injury frequency rate Australia (Elgstrand & Vingård, 2013).

Figure 11.7: Fatality rates in India (Dhoot & Dasgupta, 2013).
Figure 11.8: Rate of fatal work accidents per 100,000 workers per annum in Brazil (Elgstrand & Vingård, 2013).

Figure 11.9: Fatality rates in India ("Facts and Figures 2012", 2012).
Figure 11.10: Number of fatalities in Swedish mining and mineral industry, not including contractors (Elgstrand & Vingård, 2013).

Figure 11.11: Fatal occupational accidents in Russian arctic regions compared to Russia (1980-2009) per 100,000 workers (Dudarev, Karnachev, & Odland, 2013).
These graphs all show the decline in mining fatalities. It also seems that the trend has somewhat slowed down in the last few years. This is evident from data of Australia and Sweden, for example. However, the number of fatalities in these two countries is very low (one or a couple per year).

11.3 Causes
Mining fatalities can have several different causes. Among these, the most common are

- gas or dust explosions
- electrical burns;
- fires;
- the collapse of mine structures;
- rock falls from roofs and side walls;
- flooding;
- workers stumbling/slipping/falling; or
- errors from malfunctioning or improperly used mining equipment (Elgstrand & Vingård, 2013).

11.4 Discussion
Fatalities in mining overall have declined since the late 1900s. This is evident when looking at fatality statistics from different countries. But even with this sharp decline, the fatality rate is still high compared to other sectors. This means that more work in safety is still required, especially as the fatality rates seems to be flattening out and not continuing in their decline.

When doing the comparison of fatality statistics between countries, Australia is a country that stands out with its low numbers. From the statistics it seems some of the world’s safest mining is being performed in Australia. This leads to the question of what are they doing differently compared to other countries. A quick look at mining in Australia show comprehensive
rules and regulations, a high-perceived value of safety and a strong safety culture.

11.5 **Tools and Documentation**

12. Cost of Occupational Injuries

When an injury occurs at a workplace is comes at a cost, not just in suffering of the injured person, but also to the company and society. And while most people first consider the monetary cost to the employer in doctor’s visits, medical bills, rehab and salary, research show that it is not these direct costs that mostly contribute to the total cost of an occupational injury.

The costs of occupational injuries presented here are not specific to occupational injuries in mining, but general costs that apply to all economic sectors. This section has been included to demonstrate that there are also economic incentives to working towards improving the health and safety in the mining industry.

The following sections will describe direct and indirect (or insured and uninsured or visible and hidden) costs and how these affect the company, the individual and society.

12.1 Direct Cost

Direct (or visible) costs are those that can be readily associated with an accident. This includes things such as workers’ compensation payouts, medical bills and legal fees. Most of these costs affect only the employer.

12.2 Indirect Costs

Indirect (or hidden) costs are those costs that are directly attributable to the injury but not readily recognized. Indirect costs include loss of productivity, investigation costs, interview time, harm to reputation and morale etc. Apart from not being easily identified, the costs can also be difficult to calculate in monetary terms.

12.3 The Iceberg Theory

One way of presenting the relationship between direct and indirect cost is through Heinrich model of the iceberg. This model illustrates how the readi-
ly associated costs of an injury only makes up a small part of the actual cost of the injury (see Figure 12.1).

As well as illustrating the visible and hidden costs, the model above shows the payback of money spent on safety prevention. The report by Mine Safety and Health Program Technical Staff (2011) refers to the American Society of Safety Engineers study, showing that every $1 spent on prevention can lead to $3-6 in loss avoidance.

12.4 Effects of Workplace Injuries
A workplace injury will infer costs, not just on the injured person and its employer, but also on society (see Figure 12.2).
Figure 12.2: Distribution of cost categories of accidents at work and work-related ill-health to individuals (European Commission, 2011).

The following sections will explain the cost of a workplace injury for the three parties.

12.4.1 Company

The visible costs of an injury for the employer include sick pay, medical payments and rehabilitation of the injured person.

The hidden cost for the employer involves disruption of the work process, lower quality, staff time for reporting and investigation, material damage, repairs, affected delivery times, bad reputation and more negative safety statistics that may lead to increased difficulties in acquiring work.

The European Commission (2011) refers to Pujoal and Maroto for an illustration of the hidden costs of an accidents that leads to reduced business benefits (see Figure 12.3).
The figure illustrates how an accident not only incurs cost through the injured worker and lost time, but also how an accident can lead to a demotivated staff and staff rotation. This leads to the need to recruit new staff, resulting in further costs for the organisation.

12.4.2 Individual

The most obvious effect of a workplace injury is the physical and mental suffering of the worker. Human cost, also called pain and suffering cost or intangible costs, is the diminishment of health, psychological well-being, and family and social interactions arising from the injury. This is difficult to calculate in monetary terms but researchers, for example Lebeau, Duguay, & Boucher (2013), has used methods such as health status index in combination with the willingness-to-pay method for calculations.

The financial losses that can be more easily calculated are those of sickness compensation, which is less than the lost earnings, legal costs, and aids. Fur-
Furthermore, a lower income affects future pensions. This does not include things such as lost career opportunities and personal development.

Table 12.1 lists the consequences from an accident at work for the victim and its family and friends.

**Table 12.1:** Consequence of a workplace injury to the victim and its family and friends (adapted from European Commission, 2011).

<table>
<thead>
<tr>
<th>Victim</th>
<th>Family and friends</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong></td>
<td></td>
</tr>
<tr>
<td>Loss of earnings</td>
<td>Financial loss</td>
</tr>
<tr>
<td>Reduction of professional capacity</td>
<td>Extra household help</td>
</tr>
<tr>
<td>Medical costs</td>
<td></td>
</tr>
<tr>
<td>Unemployment</td>
<td></td>
</tr>
<tr>
<td><strong>Social</strong></td>
<td></td>
</tr>
<tr>
<td>Strain on relationships</td>
<td>Time loss</td>
</tr>
<tr>
<td>Lowered self-esteem, self-confidence</td>
<td>Lifestyle changes</td>
</tr>
<tr>
<td>Lifestyle changes</td>
<td>Strain on relationships</td>
</tr>
<tr>
<td>Affected mental health</td>
<td></td>
</tr>
<tr>
<td><strong>Clinical</strong></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td></td>
</tr>
<tr>
<td>Disease, injury</td>
<td></td>
</tr>
<tr>
<td>Limited physical capabilities</td>
<td></td>
</tr>
<tr>
<td>Permanent disability</td>
<td></td>
</tr>
</tbody>
</table>

**12.4.3 Society**

The direct cost of a workplace injury on society includes compensation and welfare payments, compensation for medical payments and travel costs.

Indirect costs include the reduction in society’s production capacity and welfare (e.g. lost taxes).
12.5 Discussions

Legislative requirements forces mining companies to work with health and safety. However, studies have found that the cost of an injury is often much higher than many realise. When including human cost, workers are the group that is affected by the highest cost according to Lebeau et al. (2013). Figure 12.4 shows the findings of Lebeau et al. (2013): the cost of occupational injuries in mines per the economic agent that assumes them.

![Figure 12.4: Cost of occupational injuries in the mining industry by economic agent Quebec, 2005-2007 (Lebeau et al., 2013).](image)

If the human cost is excluded, the numbers look very different; the employer is then affected by 64% of the cost, and the community and worker both by 18%. However, Lebeau et al. (2013) also found that human costs account for nearly 62% of the total cost and nearly 90% of the costs for workers (see Figure 12.5).
An example of the costs an injury can incur on employers, workers and community is from the study conducted by Lebeau et al. (2013) on occupation injuries in mining, 2005-2007, which is presented in Figure 12.6. The figure shows the total cost of an occupational injury is almost three times as high for the worker compared to the employer.
Figure 12.6: Cost associated with occupational injuries in one year in the mining industry, Quebec, 2005-2007 (Lebeau et al., 2013).

Low incident rates is not just of benefit to the individual, company and society; a study conducted by ILO (2006) show a strong correlation between national competitiveness and the nation’s incidence rates of occupational accidents (see Figure 12.7).
12.6 Tools and Documentation

There are different methods and tools available to calculate the potential indirect and direct costs. Two such sources are the “calculators” available on the following sites:

- https://www.osha.gov/SLTC/etools/safetyhealth/mod1_costs.html
References


Dhoot, V., & Dasgupta, Y. (2013). Number of mining accidents falls by 56% in last 7 years. The Economic Times,


