Arto Kuusisto

Safety management systems

Audit tools and reliability of auditing

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Arto Kuusisto

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Abstract

Safety auditing is a systematic method to evaluate a company's safety management system. Auditing should cover the entire safety management system, that is, all the activities aiming to ensure adequate control of the hazards affecting people, property or the environment. The two main tasks of auditing are: 1) compliance verification to establish whether the relevant legal requirements are met, and 2) validation to see whether the correct types of methods are in use, and whether they are effectively implemented. Safety auditing is one part of the company's general management activities, and is a similar procedure to the auditing of quality and environmental management systems.

Several methods, or tools have been developed for supporting safety auditing. Typically, these methods are checklists of the activities to be assessed. Some methods also have criteria for the assessment, as well as a scoring system which produces a numerical estimate of the safety activity level. The aim of these safety audit methods is to help the company's management systematically follow the overall progress in safety control. Audit results should be reliable which means that different auditors should come to the same conclusions. In addition, reliability determines the upper limit for the validity.

This work concentrates on evaluating the reliability of some safety audit tools. Firstly, the factors affecting reliability in auditing are clarified. Secondly, the inter-observer reliability of one of the audit tools is tested. This was done using an audit method, known as the D&S method, in six industrial companies in the USA, and in three companies in Finland. Finally, a new improved audit method called MISHA was developed, and its reliability was tested in two industrial companies.

The results of the work show that safety audit tools are helpful during the safety audit process, but do not ensure reliable and valid audit results. The role of the auditor is always essential in safety auditing. The auditor's expertise in the field of health and safety is particularly important when the company's compliance with the legal requirements is evaluated.

The case studies showed that a reasonably high reliability in the use of the D&S can be achieved when the auditor is familiar with the audit tool, the national legislation, and the company's culture. The reliability decreases when the auditor is less familiar with the audit method, or the local conditions.

The D&S method is a very rough method, and it does not help the auditor to assess the individual safety activities very thoroughly. This means that there is a lot of space for the expertise of the auditor. The D&S method also suggests certain activities which may not always be the most suitable solutions for every company. In many cases, the company can arrange its activities in another way, but equally effectively. Also, it was noticed that the D&S method needs updating. For example, some criteria of the of the D&S method are very easy to meet. The method could be improved by giving less weight to areas like fire control and industrial hygiene control, and by focusing more attention to areas like follow-up and auditing.

The new MISHA method developed in this work is slightly differently constructed to the D&S method. MISHA has more activities to be assessed and also more specific evaluation criteria than the D&S method. The reliability testing revealed that MISHA gives more reliable results than D&S when the auditor is not trained. On the other hand, it seems that the D&S is more reliable when the auditor is a trained expert.

The validity of D&S and MISHA were not statistically tested. This was solely because it is difficult to determine such safety outcomes that would relate or correlate with each safety activity of the audit tool. Accident statistics, for example, do not provide sufficient data for validity studies.

Some differences were found between the companies in the USA and in Finland. The results of the assessments indicated that the organization and administration of safety activities was at a somewhat higher level among the companies in the USA. Industrial hazard control, as well as the control of fire hazards and industrial hygiene were at a high level in all companies in both countries. Most dispersion occurred in supervision, participation, motivation, and training activities. Finally, accident investigation and analysis were significantly better arranged among the companies in the USA. The results are in line with the findings of the literature survey carried out in the theoretical part of the work.

Preface

My interest in safety management systems traces back to the years when I worked at the Tampere University of Technology (TUT) during 1987-1994. Some of the material for this study is from that time. Some material for this work is also from the studies I carried out at the University of Louisville, USA in 1992-1993. I began to write this thesis when I worked at the Department of Occupational Safety of the Finnish Institute of Occupational Health (FIOH) in 1994-1996. The final modifications to this work were done while I was working at the VTT Technical Research Centre in Tampere.

I would like to thank professor Markku Mattila from TUT for supervising the work.

To Professor Waldemar Karwowski, many thanks for the scientific guidance, and for giving me the opportunity to carry out part of the work at the University of Louisville. Many thanks also to Ms Tiina Hakonen who gave me invaluable advice on the statistical problems, and performed the statistical computations. Mr Jari Schabel from the VTT Technical Research Centre has provided technical editing assistance and helped to revise the language of this work. Many thanks also to him.

I would also like to thank all those people at TUT, FIOH and VTT who have given me valuable comments to this work, and those people from the participating companies in Finland and in the USA who gave me the opportunity to carry out the case studies.

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APPENDICES

Terms and definitions

Accident: An unintentional event that causes harm to people, property or environment (Roland & Moriarty 1983).

Audit: A systematic and independent examination to verify conformance with established guidelines and standards, and to examine whether these arrangements are implemented effectively and are suitable to achieve objectives (ISO 10011-1 1990, Guidelines for ... 1993).

Ergonomics: A branch of science that aims at optimizing the functioning of a work system by adapting it to human capacities and needs (Grandjean 1988, Clark & Corlett 1984).

Hazard: An inherent physical or chemical characteristic that has the potential for causing harm to people, property, or the environment (Guidelines for ... 1993).

Incident: An unplanned event that has the potential to lead to an accident (BS 8800 1996).

Major Accident: An incident involving multiple injuries, a fatality, and/or extensive property damage (Guidelines for ... 1993).

Occupational Accident: An accident, the origins of which are from a workplace. A sudden occupational accident can take place either at the workplace, or while commuting between home and the workplace.

Reliability: An estimate of how consistently the studied behavior or phenomenon is observed by one person in different times (intra-observer reliability), or by two or more persons independently at the same time (inter-observer reliability).

Risk: The combination of the expected frequency (events/year) and consequence (effects/event) of a single accident or a group of accidents (Guidelines for ... 1993).

Safety: The quality of a system that allows the system to function under a predetermined condition with an acceptable minimum of accidental loss (Roland & Moriarty 1983).

Safety Management: A systematic control of worker performance, machine performance, and physical environment. The control includes both prevention and correction of unsafe conditions and circumstances. (Heinrich et al. 1980).

Safety Policy: A management definition of the safety and health related actions to be followed in the work organization (Petersen 1989).

Safety Program: The term "safety system" is also used. A set of policies, procedures, and practices designed to ensure that barriers to incidents are in place, in use and effective (Guidelines for ... 1993).

Safety Review: An inspection of a plant or process unit, drawings, procedures, emergency plans, and/or management systems, etc. often by a team, and usually problem-solving in nature (Guidelines for ... 1993).

Validity: An estimate of how accurately a method or a scale describes the real situation. Validity is often divided into content validity, criterion validity, and construct validity. (Downie & Heath 1970).

Work Analysis: The terms "workplace analysis" and "workplace survey" are also used. An analysis of the work and the work environment in order to determine the quality and quantity of the task-related stress factors which might affect on employee's health and safety (Landau & Rohmert 1989). In the Nordic Countries, it is also used for the work load and hazard analysis carried out by the occupational health service personnel (Rossi 1990).

Working Conditions: The employee's experience of the quality of work environment, usually with special emphasis on health and safety.

Work Environment: The physical, mental (psychological) and social environment where the employee works.

Abbreviations

AET	Das Arbeitswissenschaftliche Erhebungsverfahren zur Tätigkeitsanalyse
CE	Concurrent Engineering
CIM	Computer Integrated Manufacturing
CHASE	Complete Health and Safety Evaluation
D&S	A safety audit method originally developed by Diekemper & Spartz
DNV	Det Norske Veritas
EMG	Electromyography
ETA	Event-Tree Analysis
FMEA	Failure Mode and Effects Analysis
FSD	Fragebogen zur Sicherheitsdiagnose
FTA	Fault-Tree Analysis
HAZOP	Hazard and Operability Analysis
HSE	Health and Safety Executive (in UK)
IMVP	International Motor Vehicle Program
ISRS	International Safety Rating System
JDS	Job Diagnostics Survey
JIT	Just-in-time
κ	Kappa coefficient
κ_W	Weighted Kappa coefficient
LWIR	Lost Workday Incidence Rate
MISHA	Method for Industrial Safety and Health Activity Assessment
MORT	Management Oversight and Risk Tree
MSDS	Material Safety Data Sheet
OHS	Occupational Health Service
OSQ	Occupational Stress Questionnaire
OSHA	Occupational Safety and Health Administration (in the USA)
OWAS	Ovako Working posture Analyzing System
PAQ	Position Analysis Questionnaire
SD	Standard Deviation
SMEs	Small and Medium-Sized Enterprises
SWAT	Subjective Workload Assessment Technique
TLV	Threshold Limit Value
TLX	Task Load Index
TQM	Total Quality Management
VPP	Voluntary Protection Program of the OSHA

1. Introduction

1.1 Consequences of occupational accidents

HEALTH AND SAFETY AT WORK

Health at work typically refers to the general state of an individual's physical, mental and emotional well-being. As a minimum, health at work would mean that a person is free from illness, injury, and mental problems which impair normal activity (Ferry 1984). Today it is commonly agreed that the control of health, in workplaces and in the society in general, includes not only preventing hazards and maintaining the current health status but also the search for means to improve the well-being.

Similarly to health, *safety* is more than just a condition where a human is free from hurt, injury or loss. Grimaldi & Simmonds (1975) have defined safety as "reliable control of harm". According to this approach, the minimum level in occupational safety is achieved when the frequency and severity of occupational accidents are at an acceptable level. From a technical and organizational point of view, safety can be understood as a characteristic of a system, a similar property as quality, dependability or reliability (Roland & Moriarty 1983).

An accident is often defined as an event that causes harm to people, property or to the environment. Often they are also characterized as sudden, unexpected, and undesired occurrences. An incident can be defined as an event that has not caused loss but which could lead to an accident in other circumstances. Near-accidents, near-misses, and learning experiences are frequently used synonyms to incidents.

TYPES OF CONSEQUENCES FROM OCCUPATIONAL ACCIDENTS

Those affected by occupational accidents and incidents can be divided into the following three categories: the employees, the employers, and the public administration (Söderqvist et al. 1990, Klen 1989). The consequences to the employee include, among others, mental effects, effects on off-the-job activities, disability to work, and the effects to the economic situation (Söderqvist et al. 1990). The immaterial losses to the employee can seldom be compensated, while usually a major part of the employee's financial losses are covered by worker's compensation systems.

The costs of the employer can be divided into *prevention costs* and *accident costs* (Brody et al. (1990). Three types of prevention costs can be found: 1) fixed costs (safety and other equipment, salaries of medical personnel and safety personnel), 2) variable costs (time used for accident and risk analysis), and 3) unexpected costs (re-design and equipment modification). Similarly, the accident costs can be divided into: 1) direct costs (mainly insurance costs) and 2) indirect costs (caused by wages, material damage, administration's time, production losses, and so on). Besides these, there are costs that are difficult to measure directly. These include the company's damaged public image which may result in difficulties to hire skilled personnel, or to find customers and external financial resources.

The third party affected by accidents and incidents is the public administration. The consequences to it comprise of the lost tax revenue and production, the costs of public and private services, the costs of medical care, and the costs due to pensions (Söderqvist et al. 1990, Klen 1989).

ACCIDENT FREQUENCIES AND COSTS

In the USA, 4,800 work deaths and 3.9 million disabling injuries occurred in 1996. The total costs of these events were estimated to be 121 billion USD (Accident facts 1997). In Finland, there were 53 fatal occupational accidents in 1994, and 64 people died of an occupational disease in the same year. More than 92,000 non-fatal occupational accidents were reported, including 6,100 compensated cases of occupational disease. Almost 14,000 accidents and 29 deaths occurred while commuting to or from the place of work (Työtapaturma- ja ammattitautitilasto 1995).

Inadequate control of health and safety may also lead to a poorly designed physical work environment, as well as to unsatisfactory mental and social working conditions. These circumstances can contribute to, for example, untimely retirements. In Finland, the average age for employees to be pensioned is 59 years. In 1994, nearly 300,000 Finnish people were disability pensioners which is almost 12 % of the total workforce. In 33 % of these cases the disability was due to mental strain, and in 31 % of the cases from musculoskeletal disorders (Statistical yearbook ... 1995).

The actual number of days of absence from work is much higher than what the accident statistics show. This is because illnesses not directly related to work cause a major part of the unplanned absences. For example, the total absenteeism rate in Finnish industries was 5.3 % of the work time in 1994. This figure includes occupational accidents and illnesses as well as illnesses not related to work. (Työaikakatsaus 1995)

It is difficult to determine how much unsatisfactory working conditions contribute to financial losses in total. According to Oxenburgh (1991), poor working conditions result besides in absenteeism, also in reduced effort on the part of the employee. Employees can be at workplace but reduce, for example, the time they spend in unsatisfactory work areas. On the other hand, Oxenburgh has stated that the correlation between absenteeism rates and the quality of the work environment is not always clear. He has found that, for example, the national differences in the systems for paying and receiving compensation partially explain why absence rates are different in different countries.

1.2 Means to control health and safety hazards

Modern accident causation models are based on the assumption that the ultimate causes for accidents and incidents are in the management decisions and organizational practices. The systematic and planned top management driven activity that aims at controlling the health and safety hazards is usually called *safety management*. The terms *safety program* and *safety system* are sometimes used for describing the same function. However, the latter ones usually put less emphasis on the management's role.

The primary aim of safety management is to intervene in the causation process that leads to accidents and incidents (Booth & Lee 1995). This includes, above all, the active recognition of both visible and latent hazards. However, safety management is more than just a hazard identification system. It is an overall system for ensuring that the safety activities are properly planned, effectively implemented, and that the follow-up system is arranged. Typically safety management includes activities like risk analyses, arrangement of safety training, accident and near-miss investigations, safety promotion, and assessments of human reliability. In an effective safety management system these activities are assigned to all the different hierarchical levels of the organization. (Booth & Lee 1995, Grimaldi & Simmonds 1975).

Safety management has many parallels with the other organizational management activities. For example, Total Quality Management (TQM) and environmental hazard management have many similar elements with safety management (Krause & Hidley 1989, Successful ... 1997, Tallberg & Mattila 1994, Weinstein 1996). Development of several parallel and often overlapping management systems is always a waste of resources. Nowadays, integrated SHEQ (safety, health, environment, quality) systems have been introduced in many organizations (Spedding et al. 1993, Shillito 1995), and also models for developing an integrated system are available (e.g. BS 8800 1996).

Several safety management related standards, directives, and regulations have been published during the 1990s. This progress has been noticeable especially in Europe. The BS 8800 (1996) has became the first widely spread general safety management standard. The “Seveso” Directive 82/501/EEC (1982) presents the principles for the management of major accident hazards in the chemical and petro-chemical industry. This directive has been modified twice since it was first passed, and a fundamental revision “Seveso II” (96/82/EU), which emphasizes the control of hazards by improving the management system, was released in December 1996. Finally, the “framework” Directive 89/391/EEC (1989) which presents the basic requirements for a company’s safety policy can also be considered as a tool to be used in the development of a company’s safety management system.

1.3 Evaluation of a safety management system

The effectiveness and adequacy of the safety management system should be evaluated on a regular basis. Different evaluation methods can be used for assessing the different aspects of the safety management system. The most commonly used methods are: 1) measurement of safety performance, 2) safety audits, and 3) management reviews.

MEASUREMENT OF PERFORMANCE

Measurement of safety performance is a means of monitoring the extent to which the safety policy and safety objectives are being met, and it includes both the proactive measurement tools and the reactive tools. Proactive monitoring is used for checking compliance with the company's planned health and safety activities, while reactive monitoring is used for the investigation, analysis, and recording of the management system failures, including accidents and incidents. (BS 8800 1996).

SAFETY AUDITS

A safety audit can be done in several ways, by different people in the organization, and it can cover many different activities. In everyday language also risk analyses, technical inspections, and other plant level routine assessments are often called audits. However, when a safety audit is understood similarly to a quality system audit, it is an assessment of the *management system*. This assessment has two goals: it should verify that the minimum legal requirements are met, and that the current safety efforts are effective and sufficient. (Glendon 1995)

A safety audit should assess the company's safety status reviews, safety policy, safety organization, implementation of the safety activities, and the performance measurement systems (BS 8800 1996). Depending on the size of the company and the nature of the company's activities, one or more areas of the safety management system can be assessed during one audit process.

An audit should include personnel interviews, documentation reviews, and visits to the workplace. For auditors who want to systematize the audit process, several quantitative audit tools have been developed. The use of these tools makes it possible to follow the progress that has been achieved in the company, and in some cases these tools can be used for comparing the activity levels between different companies.

MANAGEMENT REVIEWS

The need to modify and further develop the safety management system can be distinguished in management reviews. A management system may work as planned, but any internal or external changes may require redesign of the system. Findings from the safety performance measurements and from the audits are the main sources of information for the management reviews. A good review system ensures that the company can learn from experience, improve performance, develop the health and safety management system, and respond to changes (Successful ... 1997).

1.4 Need for this study

The author has studied safety management since 1988 when he audited the first companies using the D&S (Diekemper & Spartz 1970) audit method. Since then, he has assessed the safety activities of more than 30 companies. The need for this study originally arose from the fact that very few experiences were reported on the reliability of safety auditing and safety audit tools.

In this work, the reliability of one audit tool (the D&S method) was tested using nine case study companies. Six of these companies were from the United States, and three of the companies were from Finland. This research concept made it possible to observe also some national differences in safety management practices.

A new audit tool called MISHA (Method for Industrial Safety and Health Activity Assessment) was developed. The MISHA method was developed using the experiences obtained from the nine case studies. The reliability of the MISHA method was tested in two case studies in Finnish companies. The validity of the MISHA is also discussed.

There is a distinction between the concepts of *health* and *safety* at work as was mentioned in Section 1.1. However, for reasons of simplicity, from here on the concept of *health and safety management* will be referred to in many instances as *safety management.*

2. Scope and objectives of the study

2.1 Scope of the study

In this work, safety audit tools and reliability of safety auditing is studied. Since safety auditing is an assessment of the safety management system, it is useful to first define what a safety management system is.

The elements of a typical industrial safety management system are presented in Figure 1. The following four areas of interest can be found: *government*, *public*, *installation*, and *personnel*. Two of the sectors, the government and the public, are external to the company, and a company has very limited possibilities to directly influence on them. On the other hand, the other two – the installation and personnel – are sectors that are mostly controlled by the company.

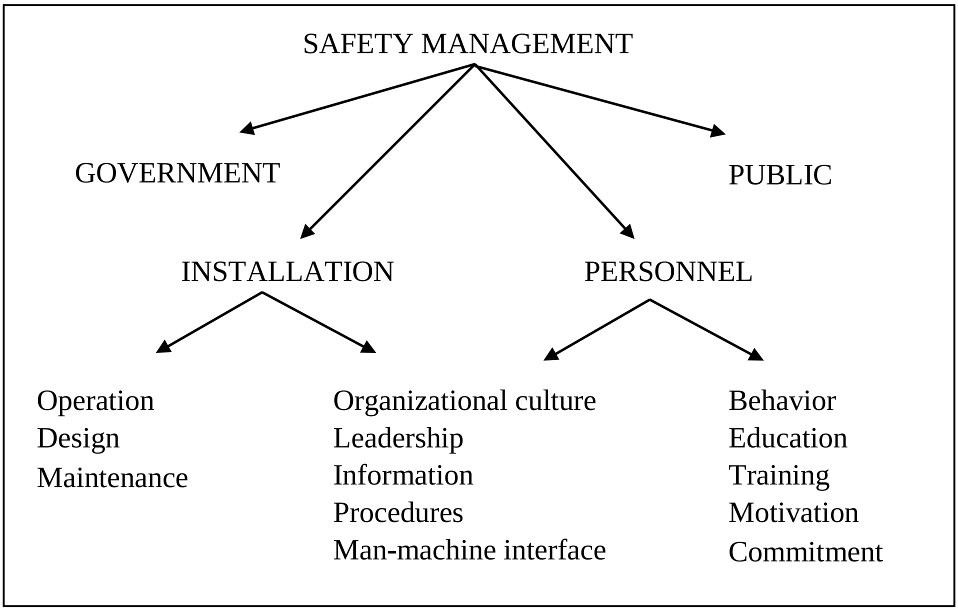

Figure 1. Safety management – the areas of interest. Adopted and modified from Safety Management Systems (1995).

This work concentrates on the two internal sectors: 1) the installation, and 2) the personnel of a company. Besides this, some government regulations are discussed when they clearly aim to influence the company's management practices. Furthermore, the public is involved in the scope when, for example, the control of major accidents hazards is discussed.

Safety auditing is an assessment of the safety activities. Thus, it not only a measurement of safety performance or safety results. Using the categorization presented by the Health and Safety Executive (HSE) in Successful ... (1987) the activity areas to be covered in an audit are:

- definition of the safety policy,
- organizing of the control, cooperation, communication, and competence management systems,
- planning and implementing of the safety activities,
- reviewing of the performance.

A safety audit process is usually divided into the following three main stages: 1) preparation, 2) on-site activity, and 3) conclusions. The first stage includes the planning of the audit, and search of the background information. The second stage consists of interviews, observations and document reviews in the workplace. In the last stage, the audit results are reported and the follow-up plan is prepared.

The auditor or auditors can prepare the audit questions individually for every audit session. However, it is also possible to use special audit tools which include a fixed list of audit questions. Some of these tools include additional features like weights for the different questions, and a scoring system which produces a numerical value for the safety activity level.

2.2 Objectives of the study

The objective of this work is to evaluate how reliable results auditing can give. It is hypothesized that:

- the auditor’s expertise in health and safety, and in the safety legislation influences the reliability of the audit results,
- a properly constructed audit tool can improve the reliability of the audit results.

A third hypothesis can be formulated from the comparison of safety activities in Finland and in the USA. This hypothesis is:

- safety activities are at higher level among the companies in the USA compared to the Finnish companies when the D&S audit method is used as the assessment method.

2.3 Framework of the study

The framework of this study is presented in Figure 2. The theoretical part of the study clarifies first the concept of safety management (Chapter 3). This is followed by a summary of safety audit techniques and a review of the characteristics of some current safety audit tools (Chapter 4).

The materials and methods used in the work are presented in Chapter 5. The material is collected mainly in case studies, carried out in industrial enterprises. In total, eleven case studies were done, Cases I-VI in the USA, and Cases VII-XI in Finland.

Chapter 6 presents the safety activities in Case study companies I-IX. Besides this, it includes the reliability tests of the D&S audit tool. The aim of these tests was: 1) to evaluate the inter-observer reliability of the D&S audit tool, and 2) to evaluate the factors influencing the reliability of the auditors. In Cases I-VI, the author and the companies' personnel acted as auditors. In Cases VII-IX, the audits were carried out by the author and 19 students of safety engineering.

Based on the results of the Case studies I-IX, a new audit tools was developed. The development of the MISHA (Method for Industrial Safety and Health Activity Assessment) is described in Chapter 7. Reliability testing of this new tool was done in two Finnish companies. In the tests, the author and four persons from each of the two companies acted as auditors. These tests are described in Chapter 8.

Discussion on the results of the work is in Chapter 9. This chapter includes summary of the results, evaluation of the problems and limitations of the research methodology, and proposal for further studies in the field.

Conclusions of the work are presented in Chapter 10. In this chapter, it is determined whether the results support the three hypotheses of the work.

Theoretical background

- safety management systems
- safety audit procedures
- safety audit tools

Reliability of the D&S audit tool

- case studies I-VI in the USA

Reliability of the D&S audit tool

- case studies VII-IX in Finland

Development of the new MISHA audit tool

Reliability of the MISHA audit tool

- case studies X-XI in Finland

Discussion

- reliability of auditing and audit tools

based on the case studies

- comparison of safety management practices in Finland and in the USA
- limitations of the research methodology
- proposals for further studies

Conclusions

- do the results support the hypothesis

Figure 2. Framework and progress of the study.

3. Safety management systems

3.1 Accident causation models

The most important aim of safety management is to maintain and promote workers' health and safety at work. Understanding why and how accidents and other unwanted events develop is important when preventive activities are planned. The most common accident causation models are presented in this section.

Accident theories aim to clarify the accident phenomena, and to explain the mechanisms that lead to accidents. All modern theories are based on accident causation models which try to explain the sequence of events that finally produce the loss.

In ancient times, accidents were seen as an act of God and very little could be done to prevent them. In the beginning of the 20th century, it was believed that the poor physical conditions are the root causes of accidents. Safety practitioners concentrated on improving machine guarding, housekeeping, and inspections.

One of the first industrial accident causation theories was presented by H.W. Heinrich in 1931. This model is now commonly known as the Domino theory. The new discovery that Heinrich presented was that in most cases an accident is the result of two things: the human act, and the condition of the physical or social environment.

Petersen (1988) extended the causation theory from the individual acts and local conditions to the management system. He concluded that unsafe acts, unsafe conditions, and accidents are all symptoms of something wrong in the organizational management system. Furthermore, he stated that it is the top management who is responsible for building up such a system that can effectively control the hazards associated to the organization's operation.

The errors done by a single person can be intentional or unintentional. Rasmussen and Jensen (1984) have presented a three-level *skill-rule-knowledge* model for describing the origins of the different types of human errors.

Nowadays, this model is one of the standard methods in the examination of human errors at work.

Accident-proneness models suggest that some people are more likely to suffer an accident than others. The first model was created in 1919, based on statistical examinations in a munitions factory. This model dominated the safety thinking and research for almost 50 years, and it is still used in some organizations. As a result of this thinking, accident were blamed solely on employees rather than the work process or poor management practices. Since investigations to discover the underlying causal factors were felt unnecessary and/or too costly, a little attention was paid to how accidents actually happened. (Cooper 1998).

Employees' attitudes towards risks and risk taking has been studied, e.g. by Sulzer-Azaroff (1987). According to her, employees often behave unsafely, even when they are fully aware of the risks involved. Many research results also show that the traditional promotion methods like campaigns, posters and safety slogans have seldom increased the use of safe work practices. When backed up by other activities such as training, these measures have been somewhat more effective (Smith 1988, Hislop 1993, Glendon & McKenna 1995). Experiences on some successful methods to change employee behavior and attitudes have been reported. One well-known method is a small-group process used for improving housekeeping in industrial workplaces (Komaki 1986, Saarela 1990).

A comprehensive model of accident causation has been presented by Reason (1990) who introduced the concept of o*rganizational error*. He stated that corporate culture is the starting-point of the accident sequence. Local conditions and human behavior are only contributing factors in the build-up of the undesired event. The latent organizational failures lead to accidents and incidents when penetrating system's defenses and barriers (Figure 3). Groeneweg (1992) has developed Reason's model by classifying the typical latent error types. His TRIPOD model calls the different errors as General Failure Types (GFTs).

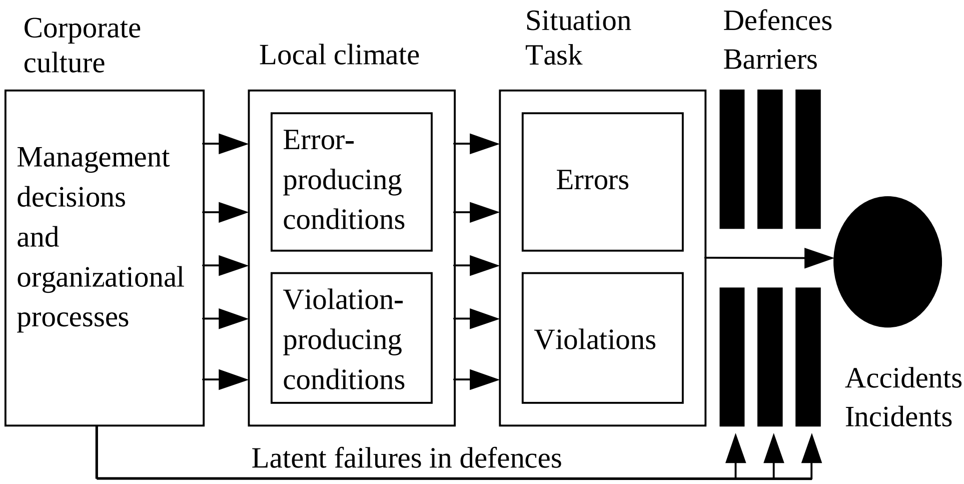

Figure 3. Stages in the development of an organizational accident (Reason 1994).

The concept of organizational error is in conjunction with the fact that some organizations behave more safely than others. It is often said that these organizations have good *safety culture*. After the Chernobyl accident, this term became well-known also to the public. The concept of safety culture is discussed more in Section 3.2.1

Loss prevention is a concept that is often used in the context of hazard control in process industry. Lees (1996) has pointed out that loss prevention differs from traditional safety approach in several ways. For example, there is more emphasis on foreseeing hazards and taking actions before accidents occur. Also, there is more emphasis on a systematic rather than a trial and error approach. This is also natural, since accidents in process industry can have catastrophic consequences. Besides the injuries to people, the damage to plant and loss of profit are major concerns in loss prevention.

The future research on the ultimate causes of accidents seem to focus on the functioning and management of the organization. The strategic management, leadership, motivation, and the personnel's visible and hidden values are some issues that are now under intensive study.

3.2 Safety management as an organizational activity

Safety management is one of the management activities of a company. Different companies have different management practices, and also different ways to control health and safety hazards. Sections 3.2.1-3.2.3 describe how the company culture and development stage can affect safety management. Section 3.2.4 clarifies the connections between safety, environmental, and quality management systems.

3.2.1 Safety culture

Organizational culture is a major component affecting organizational performance and behavior. One comprehensive definition for an organizational culture has been presented by Schein (1985) who has said that organizational culture is “a pattern of basic assumptions – invented, discovered, or developed by a given group as it learns to cope with its problems of external adaptation and internal integration – that has worked well enough to be considered valid and, therefore, to be taught to new members as the correct way to perceive, think, and feel in relation to those problems”.

The concept of safety culture is today under intensive study in industrialized countries. Booth & Lee (1995) have stated that an organization’s safety culture is a subset of the overall organizational culture. This argument, in fact, suggests that a company’s organizational culture also determines the maximum level of safety the company can reach. The ACSNI Human Factors Study Group has suggested the following as a working definition of a safety culture (ACSNI ... 1993):

The safety culture of an organization is the product of individual and group values, attitudes, perceptions, competencies, and patterns of behavior that determine the commitment to, and the style and proficiency of, an organization’s health and safety management. Furthermore, organizations with a positive safety culture are characterized by communications founded on mutual trust, by shared perceptions of the importance of safety, and by confidence in the efficacy of preventive measures.

There have been many attempts to develop methods for measuring safety culture. Williamson et al. (1997) have summarized some of the factors that the various studies have shown to influence organization’s safety culture. These include: organizational responsibility for safety, management attitudes towards safety, management activity in responding to health and safety problems, safety training and promotion, level of risk at the workplace, workers’ involvement in safety, and status of the safety officer and the safety committee.

3.2.2 National differences in safety culture

Organizations behave differently in the different parts of the world. This causes visible differences also in safety activities, both in employee level and in the management level. Reasons for these differences are discussed in the following.

The studies of Wobbe (1990) reveal that shop-floor workers in the USA are, in general, less trained and less adaptable than those in Germany or Japan. Wobbe claims that one reason for this is that, in the USA, companies providing further training for their staff can expect to lose these people to the competitors. This is not so common in Europe or in Japan. Furthermore, for unionized companies in the USA, seniority is valued very highly, while training or individual’s skills and qualifications do not effect job security, employment, and wage levels very much.

Oxenburgh (1991) has studied the total costs of absence from work, and found that local culture and legislation has a strong effect on absenteeism rates. For example, the national systems for paying and receiving compensation explains the differences to some extent. Oxenburgh mentions Sweden as a high absenteeism country, and Australia as a low absenteeism country. In Sweden injuries and illnesses are paid by the state social security system, while in Australia, the employer pays all these costs, including illnesses not related to work.

Comparison of accident statistics reveals that there are great national differences in accident frequencies and in the accident related absenteeism from work. Some of the differences can be explained by the different accident reporting systems. For example, in some countries only absenteeism lasting more than three working days is included in the statistics. (ESAW 2000). The frequency of minor accidents varies a lot according to the possibility to arrange substitutive work to the injured worker. Placing the injured worker to another job or to training is a common practice for example in the USA and in the UK, while in the Scandinavian countries this is a rarely used procedure.

3.2.3 Preconditions for improving safety management

Some organizations are more aware of the importance of health and safety at work than others. Clear development stages can be found in the process of improving the management of safety (Table 1). The table has been derived from the quality improvement model of the Baldrige National Quality Program (Criteria ... 1999).

Table 1. Development stages in the improvement of safety management.

Development stage	Typical features
Fire fighter	Problems are solved when they arise. Origins of the problems are not analyzed.
Compliance driven	Only the minimum legal requirements are met.
Risk management	A systematic method is developed for identifying and controlling hazards. Safety tasks and responsibilities are defined and communicated.
Continuous improvement	In addition to previous, safety incentives are used, improvement is encouraged through motivation and leadership.

Waring (1996) has divided organizations to three classes according to their maturity and ability to create an effective safety management system. Waring calls the three organizational models as *the mechanical model*, *the socio-technical model*, and *the human activity system approach.*

In the mechanical model, the structures and processes of an organization are well-defined and logical, but people as individuals, groups, and the whole organizations are not considered. The socio-technical model is an approach to work design which recognizes the interaction of technology and people, and which produces work systems that are technically effective and have characters that lead to high job satisfaction. A positive dimension in this model is that human factors are seen important, for example, in communication, training and emergency responses. The last model, the human activity system approach focuses on people, and points out the complexity of organizations. The strength of this approach is that both formal (or technical) paradigms and human aspects like motivation, learning, culture, and power relations are considered. Waring points out that although the human activity approach does not automatically guarantee success, it has proven to be beneficial to organizations in the long run.

3.2.4 Integration of safety to other management activities

Safety management has many similarities to quality management and environmental management. The connections between these different management systems have been widely discussed since early 1990s. The British Standard BS 8800 (1996), presents links between safety management activities, and activities included in the ISO 9001 quality standard and in the ISO 14001 (1996) environmental management standard. Weinstein (1996) has presented how the TQM development steps can be applied to the development of a safety management system. He has also outlined some of the safety activities that should be carried out to meet the ISO 9000 quality standard requirements.

Waring (1996) has listed some reasons why the integration of quality and safety can be difficult to achieve. According to him, one reason is that there can be confusion about the scope and practical requirements of these two systems. Secondly, safety is covered by a great deal of detailed legislation requiring specific management and technical systems, and many of these management systems are mandatory. Contrary to this, quality systems are voluntary and not inspected by authorities. Finally, there can be conflicting professional ambitions between the people managing these activities – causing the control of integration to become a power struggle which detracts from the actual aim.

It has also been argued that the adoption of a quality management system will not automatically lead to high standards of health and safety. For example, the use of quality standards can lead to the manufacture of safe products, but not necessarily to production processes that are adequately free from health and safety hazards (Successful ... 1997). This is also a fundamental difference between the quality management systems which aim to ensure sufficient quality of products, and the continuous improvement programs which aim to improve the overall performance of the company.

Since mid-1990s, the central management trend has been to develop comprehensive management systems that include both improvement of products and internal activities. The Kaizen philosophy (Imai 1986, Suzaki 1989) and Malcolm Baldrige Quality Award (Criteria for ... 1999) are examples of these methodologies. Besides these, Balanced Scorecard (Kaplan & Norton 1992) is a company strategy development and performance measurement tool that can also include safety elements.

3.3 Key functions of a safety management system

Effective control of health and safety requires planned activities in the organization. Together these activities form the safety management system. One of the latest safety management system models is presented in the British Standard BS 8800 (1996). It presents both the steps for creating a safety management system and methods for organizing the safety activities in practice. According to the BS 8800 standard, the main development steps are: 1) initial and periodic status review, 2) preparation of the safety policy, 3) organizing of the activities, 4) planning and implementation, 5) measurement of the performance, and 6) auditing (Figure 4).

Booth & Lee (1995) have defined the key functions of safety management as follows:

1. Policy and planning,
2. Organization and communication,
3. Hazard management,
4. Monitoring and review.

In this model, the *policy and planning* includes setting of the safety goals, determination of the safety objectives and priorities, and preparation of the working program to achieve the objectives. *Organization and communication* includes, among others, the determination of responsibilities, and the establishment of a two-way communication system to all organizational levels. *Hazard management* includes the determination and implementation of the methods for hazard identification, risk assessment, and control measures. The suitability of these methods should then be evaluated on a regular basis. Finally, *monitoring and review* ensures that the steps 1-3 are in place, in use, and work in practice.

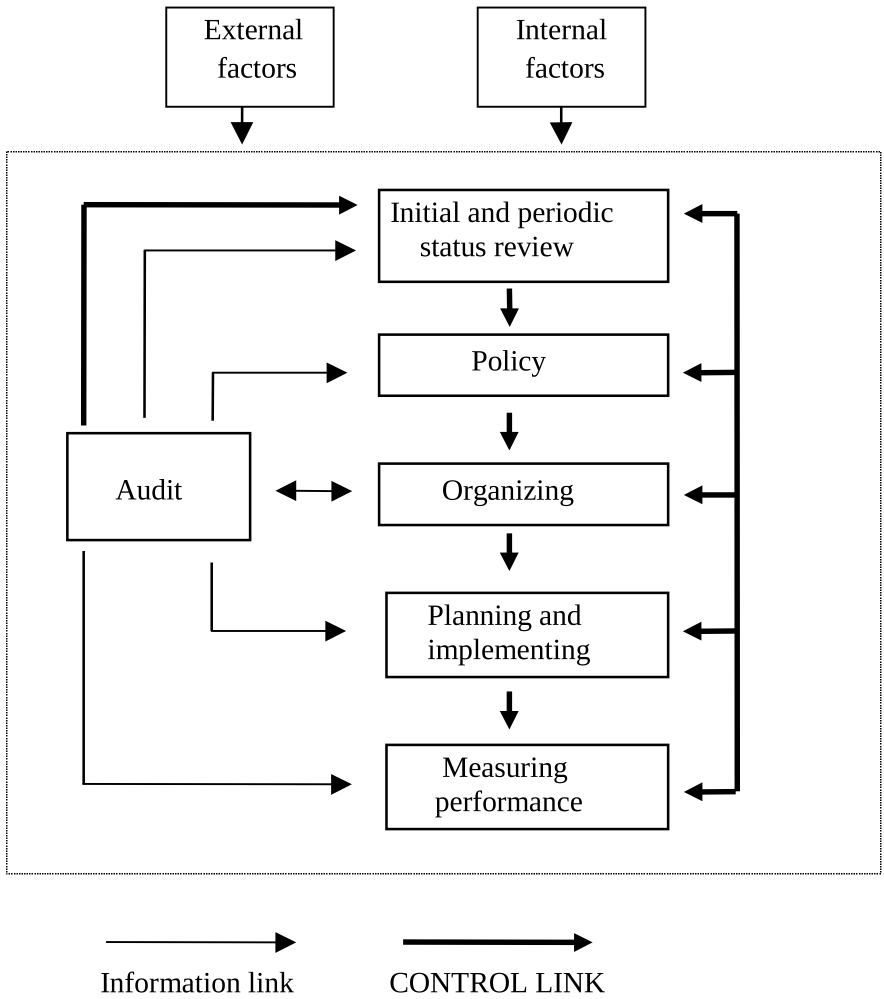

Figure 4. Elements of a safety management system (BS 8800 1996).

The elements of the Booth & Lee model are similar to those presented in the BS 8800 model. They both have the following basic activities: policy making, organizing the activities, planning and implementing the activities, and measuring the performance. These activities are discussed more detailed in Sections 3.4-3.7. The subject of Section 3.4 is safety policy and planning, and the subject of Section 3.5 is organization and communication. Hazard management is discussed in Section 3.5, and monitoring and review is discussed in Section 3.7.

3.4 Safety policy and planning

INITIAL STATUS REVIEW

A status review is the basis for a safety policy and the planning of safety activities. The review should answer to the question “where are we know?”. According to BS 8800 (1996) a status review should compare the company’s existing arrangements with the applicable legal requirements, organization’s current safety guidelines, best practices in the industry’s branch, and the existing resources directed to safety activities. A thorough review ensures that the safety policy and the activities are developed specifically according to the needs of the company.

SAFETY POLICY

A safety policy is the management’s expression of the direction to be followed in the organization. According to Petersen (1989), a safety policy should commit the management at all levels and it should indicate which tasks, responsibilities and decisions are left to lower-level management. Booth and Lee (1995) have stated that a safety policy should also include safety goals as well as quantified objectives and priorities.

The standard BS 8800 (1996) suggests that in the safety policy, management should show commitment to the following subjects:

- health and safety are recognized as an integral part of business performance,
- a high level of health and safety performance is a goal which is achieved by using the legal requirements as the minimum, and where the continual cost-effective improvement of performance is the way to do things,

- adequate and appropriate resources are provided to implement the safety policy,
- the health and safety objectives are set and published at least by internal notification,
- the management of health and safety is a prime responsibility of the management, from the most senior executive to the supervisory level,
- the policy is understood, implemented, and maintained at all levels in the organization,
- employees are involved and consulted in order to gain commitment to the policy and its implementation,
- the policy and the management system are reviewed periodically, and the compliance of the policy is audited on a regular basis,
- it is ensured that employees receive appropriate training, and are competent to carry out their duties and responsibilities.

Some companies have developed so-called “safety principles” which cover the key areas of the company’s safety policy. These principles are utilized as safety guidelines that are easy to remember, and which are often placed on wall-boards and other public areas in the company. As an example, the DuPont company’s safety principles are the following (Scott 1993):

1. All injuries and occupational illnesses can be prevented.
2. Management is responsible for safety.
3. Safety is an individual’s responsibility and a condition of employment.
4. Training is an essential element for safe workplaces.
5. Audits must be conducted.
6. All deficiencies must be corrected promptly.
7. It is essential to investigate all injuries and incidents with injury potential.
8. Off-the job safety is an important part of the safety effort.
9. It is good business to prevent injuries and illnesses.
10. People are the most important element of the safety and occupational health program.

PLANNING OF SAFETY ACTIVITIES

The safety policy should be put into practice through careful planning of the safety activities. Planning means determination of the safety objectives and priorities, and preparation of the working program to achieve the goals. A company can have different objectives and priorities according to the nature of the typical hazards, and the current status of hazard control. However, some common elements to a safety activity planning can be found. According to BS 8800 (1996) Annex C the plan should include:

- appropriate and adequately resourced arrangements, competent personnel who have defined responsibilities, and effective channels of communication,
- procedures to set objectives, device and implement plans to meet the objectives, and to monitor both the implementation and effectiveness of the plans,
- description of the hazard identification and assessment activities,
- methods and techniques for measuring safety performance, and in such way that absence of hazardous events is not seen as evidence that all is well.

In the Member States of the European Union, the “framework” Directive 89/391/EEC (1989) obligates the employer to prepare a safety program that defines how the effects of technology, work methods, working conditions, social relationships and work environment are controlled. According to Walters (1996), this directive was originally passed to harmonize the overall safety strategies within the Member States, and to establish a common approach to the management and organization of safety at work.

Planning of the safety activities is often done within the framework of quality and environmental management systems. Integration of SHEQ (safety, health, environmental, and quality) management systems was discussed more detailed in Section 3.2.4.

3.5 Organization and communication

Safety policy and safety plan set the framework for health and safety activities. Organizing the activities means that clear tasks and responsibilities are determined to all hierarchical levels, from top management to every employee. Besides this, organization’s safety related decisions and desires must be effectively communicated to the personnel. These two issues are discussed in this section.

3.5.1 Safety tasks and responsibilities

Line managers, supervisors, and the safety experts are usually those who are responsible for putting the safety policy and plan into practice. The roles of the different personnel groups must be clear before the activities can be realized.

Small and medium-sized enterprises (SMEs) are often in different situation compared to large-scale companies. SMEs can seldom employ trained health and safety experts, such as a full-time safety manager or medical personnel. In such a case, it is beneficial if the person responsible for organizing the safety activities knows how to utilize external services provided, for example, by the insurance companies or safety authorities.

National legislation often obligates companies to build up certain types of formal safety organizations, safety practices and safety documentation. However, most safety activities can be defined by the company itself. The key activities of the various personnel groups are discussed in the following.

ROLE OF THE TOP MANAGEMENT

The top management is a person or a group of persons who plan the company's strategies and determine the company's long-term goals. Organizational culture and safety culture are both strongly influenced by the top management. Thus, it can be said that top management is eventually responsible also for the defects in the organization's safety performance. Heinrich et al. (1980) have summarized this by saying that organizational failures are caused by management which allow human failures – due to knowledge, attitude, fitness, or ability – to take place. These failures then cause or permit unsafe acts, and contribute to unsafe mechanical and physical conditions.

The top management's task is to control the health and safety hazard by establishing the management system, by planning how it is implemented, and by following the outcomes of the system. For this, the top management must set up a safety policy and follow its implementation. By monitoring the activities and performance, top management can follow how the predetermined criteria have been realized, and set the new goals. (Petersen 1989, Smith 1988, Hislop 1993)

ROLE OF THE LINE MANAGER

In industrial companies, line managers typically have positions like a production manager or a quality engineer. Petersen (1989) claims that the line manager is more a key person in safety than the supervisor. He defines line management's most important safety activities as: 1) ensuring supervisor performance, 2) ensuring the quality of supervisor performance, and 3) participating personally to show visible commitment.

Ensuring supervisor performance means that the line management provides the necessary resources and support to the supervisor (Petersen 1989). For motivating the supervisor to continuously work for better safety results, the line manager should build an incentive system (Hislop 1993). Safety performance can also be used as a measure of the supervisor's management capability (Petersen 1989).

ROLE OF THE SUPERVISOR

Supervisor is often in a very demanding position in the organization. Supervisor has to be a good organizer, a talented strategic manager, a leader of the personnel, and an expert in many practical questions, including safety issues.

Leadership is a characteristic that is usually seen as essential in a supervisor's work. Supervisor is the person who is in close contact to the workers in everyday work. Thus, the supervisor is also one of the most important individuals in the organization's hierarchical structure in terms of promoting safe work practices (Hislop 1993).

Many supervisors act today as team leaders. In a team, the supervisor can use less time for controlling the work, and more time is used for planning the work, allocating resources, exploring new innovations, and motivating the team members. According to Tjosvold (1991), good social skills is a central qualification that every team leader should have.

ROLE OF THE DESIGNER

Health and safety considerations are often inadequate when work, workplaces and production processes are designed. According to Lund et al. (1993), the three major factors that influence any design process are time constraints, technical feasibility considerations, and financial and economic considerations. Several studies have shown that it is actually the expertise, training and values of an individual designer that determine to what extent safety and health is taken into account in the design process. (Main & Ward 1992, Isotalus & Kuusisto 1992, Haslegrave & Holmes 1994)

Clemens (1999) calls the traditional design process as *serial design*. In this process, the system design is executed by one group of specialists, and after that another group evaluates the operational risks these designs pose. An alternate *concurrent engineering* approach lets the designer conduct safety and reliability analyses as parallel activities, and they can accompany the design throughout the design progression. Other benefits of this concurrent approach are that the resulting design can be realized on an earlier schedule, and less man-hours are needed because potential shortcomings are identified and addressed as they are encountered.

Participation in design means that the design process, or at least part of it is performed in groups composed of employees, management and designers. The idea of participatory design is based on earlier, mainly Japanese, production development methods like production cells, teamwork, just-in-time, Kanban, and quality-circles (Noro 1991).

The designer's responsibility to carry out adequate health and safety considerations is now written in legislation in many countries. Partly due to this, the quantity of standards, handbooks and other guidelines on how to improve safety in design has increased. As an example, the basic concepts and general principles for safety in the design of machinery are presented in the European standard EN 292-1 (1991).

ROLE OF THE SAFETY PERSONNEL

The safety personnel consists usually of a *safety manager*, and a *safety representative* (or safety delegate). The safety manager is usually a line management level person appointed by the employer, while the representative is elected from amongst and by the employees. In small and medium-sized companies, the safety manager and the safety representative often have other duties besides their health and safety tasks.

Typically, the *safety manager's* role is to act as an expert who is aware of the health and safety legislation and other obligations concerning the company. Denton (1982) has summarized the safety manager's duties as follows: to promote health and safety activities, to control training needs and incentives for safe performance, to improve performance evaluation, and to increase the status and recognition of the safety function. Besides this, safety manager as an internal expert should be aware of the appropriate risk analysis methods.

In some countries, national legislation gives the employees – in certain circumstances – the possibility to elect a *safety representative*. In Finland, the safety representative's tasks and responsibilities are determined in the Occupational Safety Act (Työturvallisuuslaki 1993). The representative's main task is to follow the status of safety at the workplace, and to report to the management on potential health and safety hazards. A safety representative can stop a work that includes an obvious and immediate health danger, but otherwise the representative's enforcement power is very limited.

The safety personnel are often in a very difficult position in a company. For example, the safety manager's ability to access top management is not self-evident. Ferry (1987) has found that, regardless of the expertise and efforts, safety experts are often unable to get support for safety and health policies and programs. Lark (1991) has stated that the lack of safety personnel's power is partly the fault of the safety personnel themselves. According to Lark, safety must be sold to the management and the personnel. This in turn means that safety professionals need to be safety leaders who are able to apply modern leadership concepts to safety activities.

ROLE OF THE SAFETY COMMITTEES

Company-level organizations which carry out consultation and decision-making on occupational health and safety are common in most European countries (Walters 1996). Often these cooperative organizations are called *safety committees*. Some countries also have legislative provisions that create safety committees or other corresponding institutions at the workplace.

In Finland, a workplace having 20 or more employees should establish a safety committee or some other cooperative safety organization. Half of the committee members must represent the employees, and the other half the employer. The committee should prepare an annual action plan, evaluate the needs for internal safety inspections, assess the company's safety policy, and make suggestions for how the company's safety training and safety communication procedures should be improved (Työturvallisuuslaki 1993). In Finland, the safety committee's role is more advisory than executive. However, since committees include employer participation, they probably have more decision-making power than, for example, a safety representative alone.

In the USA, company-level safety committees are voluntary institutions. An "American" approach to safety committees has been presented by Petersen (1989). He has stated that a safety committee is not a prerequisite to successful safety results. He argues that when management takes care of preparing a safety policy, fixing accountability, and training supervisors and employees, then safety committees probably are not necessary. Petersen summarizes that it is hard to imagine a situation where a committee would be better a solution than a good management-directed control.

ROLE OF THE OCCUPATIONAL HEALTH SERVICE (OHS) PERSONNEL

In most industrialized countries, the employer must provide occupational health services to the personnel. Walters (1996) has studied the nature and coverage of the OHS systems in Europe and found that these services vary a lot from country to country. For example, in countries like Finland and the Netherlands, the OHS system provides both medical treatment, and preventive measures. In those European countries where the OHS personnel consist only of persons in the medical profession, the preventive activities are not so common. This is especially the case in France and the other Latin countries.

In Finland, the OHS personnel's work includes the identification and evaluation of work-related health hazards using methods like observations, interviews, and industrial hygiene measurements. Furthermore, in Finland, the company is obliged to organize and finance the OHS for all employees irrespective of the enterprise size (Työterveyshuoltolaki 1978). Up to 50 % of the costs can be reimbursed if the service meets certain conditions. The company can arrange these services either by itself or it can use private or municipal health service providers. According to Walters (1996), about 85 % of the Finnish employees are covered by an OHS system, which is the highest proportion in Europe. The lowest figures of coverage are in Spain (15 %), and in Portugal (13 %).

The OHS personnel's expertise can be utilized also in the workplace design. According to several reported case studies, the OHS personnel's contribution has significantly improved the quality of work environment. (Mattila & Kivi 1991, Kuusisto & Kiiskinen 1993, Kuusisto 1994)

ROLE OF THE EMPLOYEE

The employer is always responsible for ensuring the health and safety at work. In principle, the employee's task is only to obey employer's instructions and not to take any unnecessary risks. However, this kind of purely rule-based safety behavior seldom exists any more. Nowadays, employees have more decision-making possibilities regarding their own work, and often they also participate in the design of their own work methods and work environment. Furthermore, team organizations have remarkably changed the employee/supervisor relationship as was mentioned in the context of the role of the supervisor.

According to Petersen (1989), the employee's role in health and safety has changed simultaneously with the change in management and leadership styles. When management evolves towards true participation, also the role of the employee enlarges. This, in turn, means that employees will become responsible for their own actions at work, and they will also be responsible to a greater extent for running the safety system.

3.5.2 Safety communication

Communication is often the single most important area to be improved in a company. One conclusion from most organizational assessments is that there is not enough and relevant information available, and that the two-way information flow is inadequately arranged. The messages that top management wishes to communicate are not always the ones employees receive or see as relevant. On the other hand, it is common that employees feel their own ideas and needs are not sufficiently heard on the higher levels.

According to HSE, the following safety related information is the minimum that should be communicated within the organization (Successful ... 1997):

- the meaning and purpose of the safety policy,
- the visions, values and beliefs which underlie the policy,
- the commitment of senior management to the implementation of the policy,

– plans, standards, procedures and systems relating to implementation and measurement of performance,
– factual information to help secure the involvement and commitment of employees,
– comments and ideas for improvement,
– performance reports,
– lessons learned from accidents and other incidents.

Furthermore, the HSE emphasizes that management can communicate strong signals about the importance of health and safety when leading by example. Line management can show visible commitment, for example, by carrying out regular informal health and safety tours, by chairing meetings of the central health and safety committee, and by active involvement in investigations of accidents, illnesses and incidents.

Besides the management safety tours, there should be other face-to-face discussions. These can include: 1) planned meetings, for example team briefings where safety critical tasks are discussed, 2) health and safety issues on the agenda at all routine management meetings, 3) monthly or weekly meetings where supervisors discuss health and safety with their teams, and where the employees can have opportunity to make their own suggestions. (Successful ... 1997)

According to HSE, the most important written communications are the health and safety policy statements, organization documents showing the health and safety roles and responsibilities, the documented performance standards, the supporting organizational and risk control information and procedures, and the significant findings from risk assessments.

Health and safety documentation should follow the company's standard documentation procedures. For example, health and safety responsibilities should be presented in conjunction with the other responsibility descriptions. Similarly, information on the required personal protective equipment should be integrated into the general work instructions.

The company must communicate not only within the organization, but also to outside organizations and to the public. This includes informing the authorities on accidents and illnesses, and dangerous substances used at work. In some industrial branches, e.g. in the chemical industry, authorities also require information on emergency plans and risk assessments carried out in the company. Companies handling large amounts of hazardous chemicals usually must inform also the public on the potential hazards.

3.6 Hazard management

3.6.1 Hazard identification process

Hazard management includes the determination and implementation of the methods for hazard identification, risk assessment, and control measures (Figure 5). The steps presented in Figure 5 are discussed in the following sections.

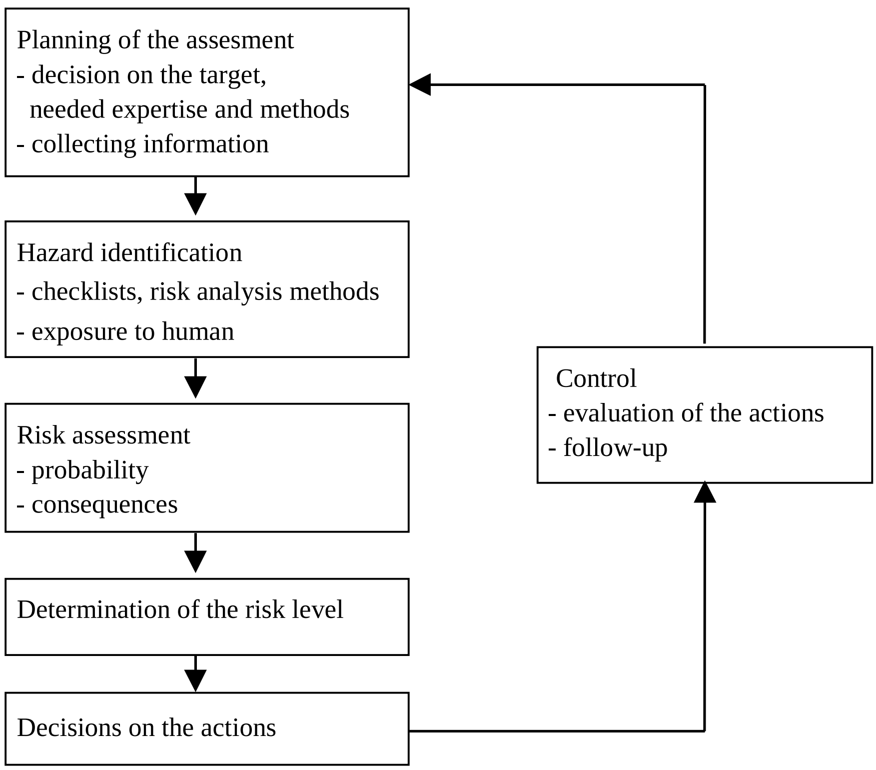

Figure 5. Steps of a typical hazard identification process.

3.6.2 Planning of the hazard analysis

Hazard identification can be targeted to one or more physical areas of the company, and it can cover several different types of hazards. The analysis can be general or detailed. When there is little existing information on the potentially hazardous equipment, machinery or tasks, it is advisable to begin by identifying the most critical units, and continue there on a more detailed level.

Some analysis techniques require more expertise than others. In the most simple case, a supervisor can carry out the analysis using a checklist during a walk-through. In a more complicated analysis, for example when potential major accident hazards are assessed in a process plant, the analysis requires the use of a systematic method and a group of several professionals, including plant engineers, chemists, and automation system experts (Lees 1996).

Determination of the suitable analysis method can be a demanding task. When a wrong analysis method is selected, there is a danger that only part of the hazards are identified. Analysis of a complicated technical system requires usually the analysis of both the technical system and the possibility of human errors.

3.6.3 Accident investigation as a source of information

Collecting information on the current safety control practices is part of the hazard analysis. Information should be collected from the active and reactive monitoring systems (cf. Section 3.7.2). Accident investigation is the most commonly used reactive hazard monitoring method.

The use of a systematic method in accident investigation and in the recording of the investigation results improves the usability of the accident data. A thorough investigation considers both the human contribution, and the physical environment. This kind of approach can reach the level where also some of the underlying organizational shortcomings can be identified (Denton 1982).

Tuominen & Saari (1982) have developed one of the systematic investigation methods which consider both *unsafe acts* and *unsafe conditions*. In this method, the analysis is divided into two main sectors: 1) investigation of the build-up and presence of the injuring energy, and 2) investigation of the actions of the person injured. In Finland, this method is used on a standard basis by the authorities in the investigation of severe occupational accidents.

Studies of Groeneweg (1992) have shown that accident investigations are predominantly directed at causes low in the organizational hierarchy. For this reason, most measures to improve safety are also directed at the employee, and less at higher levels in the organization. Groeneweg states that this can easily lead to an underestimation of the corporate culture's role in the accident causation.

Groeneweg has also pointed out that the number of events alone is not a sufficient indicator to show whether accident hazards are in control or not. Latent accident hazards may exist even though records show sufficient control. For example, accidents are typically rare in highly automated chemical process plants, but often severe when they involve a process release, a fire, or an explosion.

3.6.4 Methods for hazard identification

Thorough identification of the potential hazards can require the use of several different analysis methods. Hazards can be related to the technical system or production process, or to the human acts and behavior. Hazards can also be categorized according to their potential effects. The personnel can be in danger, the surrounding population can be affected, the property can be damaged or the environment can be harmed. In the following, the different types of hazard identification techniques are summarized.

WORKPLACE CHECKLISTS

Checklists are easy-to-use methods for identifying accident hazards related to the physical environment or to the human behavior. Some checklists are very general, while some are developed for a very specific type of environment. An example of a general purpose industrial checklist is the "Major Hazard and OSHA Checklist" presented by Heinrich et al. (1980). Checklists are typically used during a walk-through in the workplace. Some checklists include an option to calculate a safety index which describes how many elements of the checklist are in order and how many require improvement.

RISK ANALYSIS METHODS

Risk analysis is a systematic examination method, and most commonly used in industrial installations. It aims at identifying the potential accident contributors, evaluating the amount of risk, and finding risk-reducing measures. Risk analysis methods can identify system failures following both from technical defects and human errors. The term “safety analysis” is often used in the same meaning as “risk analysis”. However, there is a tendency to use “risk analysis” merely in the field of major hazards, and the term “safety analysis” in the field of occupational and product safety. (Suokas 1985)

Risk analysis methods used mainly in process industry include HAZOP, FMEA, FTA, and ETA. HAZOP (Hazard and Operability Analysis) is a systematic risk analysis method in which process deviations and potential operating problems are identified using a series of guide words (Lees 1996). FMEA (Failure Mode and Effects Analysis) is based on a tabular form to which the components of the system and their failures and failure modes are listed (IEC 812 1985). FTA (Fault-Tree Analysis) models the sequence leading to the hazard, the so-called TOP-event (Roland & Moriarty 1983). ETA (Event-Tree Analysis) models the potential consequences of failures or events (Wells 1980). Both FTA and ETA can also be used as quantitative methods. Suokas (1985) has studied the reliability and validity related to some of those risk analysis methods.

MORT (Management Oversight and Risk Tree) is a comprehensive tool for managing a company’s safety activities (Johnson 1980). Through the MORT analysis, the adequacy, as well as the realization of the safety activities, can be followed. While the previously described risk analysis methods mainly aim at locating hardware deficiencies and human errors, MORT also assesses the management system.

METHODS TO EVALUATE EXPOSURE TO HUMAN

The stress-strain model presented by Landau & Rohmert (1989) is a practical way to study an individual’s relationship to the work environment (Figure 6). The model can be used for studying an individual’s coping with the different physical, mental, and to some extent the social factors at work.

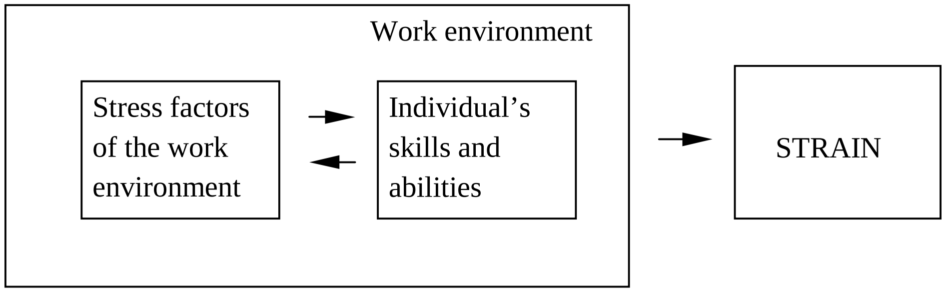

Figure 6. Simplified stress-strain model (adopted from Landau & Rohmert 1989).

Stress factors are commonly divided into two main categories: 1) physical hazards, and 2) mental (psychological) hazards. This division is useful, but not quite accurate, since these two factors are often linked together. For instance, mental strain can cause physiological symptoms, and physical hazards like high noise level or unsatisfactory thermal conditions can contribute to experienced mental overload. A list of the typical physical hazards and their identification methods is presented in Table 2.

Table 2. The types of physical hazards, and examples of their identification methods.

Physical hazards	**Typical identification methods**
Physical energies	Measurement of noise, vibration, illumination, temperature, radiation, and air flow. Health tests, e.g. eyesight and hearing tests.
Muscular work load	Analysis of working posture and manual working tasks. Health tests, e.g. fitness tests.
Chemical and biological substances	Evaluation of the harmful effects of chemicals. Industrial hygiene measurements.

The concept of mental stress or (psychological stress) was introduced after the second world war in the field of medicine (Grandjean 1988). Mental stress at work is difficult to measure, because of the great variation in the experienced stress between individuals. What is overload to one person can be a balanced situation, a positive experience, or even a challenge to another person.

However, some characteristics of the work environment can be considered as potential sources of harmful mental stress. The quality and quantity of these characteristics can be measured from the work environment itself by using suitable work analysis methods. Examples of these methods are PAQ (Position Analysis Questionnaire) (McCormick et al. 1979), AET (Das Arbeitswissenschaftliche Erhebungsverfahren zur Tätigkeitsanalyse) (Rohmert & Landau 1979), and FSD (Fragebogen zur Sicherheitsdiagnose) (Hoyos 1988). Elo (1994) has developed a checklist that is designed specially for the analysis of mental stressors at work.

An individual's experienced stress can be measured by questionnaires, interviews, and other methods like physiological measurements. Questionnaires and interviews include methods like JDS (Job Diagnostics Survey) developed by Hackman & Oldham (1975), and OSQ (Occupational Stress Questionnaire) developed by Elo (1994). The correlation between mental strain and physiological symptoms like heart rate, blood pressure and hormone secretion has been known since 1940s (Grandjean 1988).

The social environment comprises of the relationships between people, and it is one potential source of mental stress. Social environment is strongly influenced, e.g. by the organizational culture, the management's performance, and supervisor's leadership style. The personnel's work motivation, commitment, job satisfaction and behavior, among others, reflect the quality of the social environment.

3.6.5 Risk assessment

Risk assessment is a procedure where the severity of the identified hazards are evaluated. In a risk assessment, the distinction between hazard and risk must be clear:

- hazard is a source of potential harm, damage or situation,
- risk is the combination of the likelihood and the consequences of a specified hazardous event (accident or incident).

The basic steps of a risk assessment include: 1) identification of hazards, 2) estimation of the risk from each hazard, and 3) decision if the risk is tolerable (BS 8800 1996). When the hazards have been identified, the risk estimation can be done using, for example, a risk matrix presented in Table 3.

Table 3. A simple risk level indicator (risk matrix) (BS 8800 1996).

	Slightly harmful	**Harmful**	**Extremely harmful**
Highly unlikely	TRIVIAL RISK	TOLERABLE RISK	MODERATE RISK
Unlikely	TOLERABLE RISK	MODERATE RISK	SUBSTANTIAL RISK
Likely	MODERATE RISK	SUBSTANTIAL RISK	INTOLERABLE RISK

The likelihood of an event should be evaluated using information on the number of persons involved, frequency and duration of exposure, failures in services (e.g. electricity and water), reliability of the machinery and its safety components, protection available to personnel, and unsafe acts of the personnel. The severity of harm can be evaluated from the information on parts of the body likely to be affected, and the nature of the harm (e.g. superficial harms, lacerations or deafness, permanent minor disability, multiple injuries, fatal injuries, occupational cancer, or acute fatal disease).

Whether a risk is tolerable or not can be difficult to define. For this reason, it is more practicable to determine which activities the company should take in connection with each risk level. The BS 8800 (1996) Appendix D presents a table where each risk level is given actions and a time-scale. According to this table, a trivial risk needs no attention, a tolerable risk needs monitoring, a moderate risk requires efforts to reduce the risk, a substantial risk causes that the work should not be started before the risk is reduced, and when an intolerable risk has been identified the work should not be started or continued.

3.6.6 Control activities

Hazards should be controlled on a regular basis in order to ensure that the risks associated to them do not increase above an acceptable level. It is self-evident that the activities determined based on the risk assessment must be completed. When necessary, a separate monitoring system should be established.

The control of hazards should be a continuous process. According to Petersen (1989) the continuous control can be achieved by combining the following methods:

- engineering control, including elimination or minimization of exposure by material or process modification, changing a hazardous material to a less hazardous one, isolation of worker or process, ventilation, and plant layout and design,
- monitoring of the process and the environment, and by health surveys,
- promoting of good and safe work practices,
- education and training,
- scheduled maintenance program,
- providing protective equipment when needed.

It can be asked what is the adequate effort to minimize the risk. It is obvious that the minimum legal requirements must be met. This means, for example, that the machinery must be safeguarded, and the safety documentation required by the authorities is prepared. However, many requirements can only be expressed by the phrases “so far as is practicable” or “as low as reasonably possible”. These expressions include the idea that the level of risk in a particular case can be balanced against time, trouble, cost, and physical difficulty of taking measures to avoid the risk (Successful... 1997).

3.7 Monitoring and review

3.7.1 Overview

Monitoring an organization’s performance is a complex job. It requires the definition of which parameters describe best the different areas of the organization’s performance. Safety is typically something that cannot be measured purely using economic measures. For example, it is often difficult to see, how investments to improve safety increase profitability. Thus, investments to safety must be seen as something that improve profitability indirectly, for example through better customer satisfaction, improved quality of products or services, better internal effectiveness, and better employee satisfaction.

The Health and Safety Executive (HSE) has divided the monitoring procedures into: 1) measuring performance, 2) auditing, and 3) reviewing performance (Successful ... 1997). The HSE model is identical to the BS 8800 framework of the main safety management activities (see Figure 4 in Section 3.3) except that the “reviewing performance” activity is not included in the BS 8800 standard.

Measuring performance is discussed more detailed in Section 3.7.2. The principles of auditing are presented in Section 3.7.3. Reviewing performance is discussed in Section 3.7.4.

3.7.2 Measuring performance

According to HSE (Successful ... 1997), assessment of a safety management system requires two types of measuring systems. The *active systems* monitor the design, development, installation, and operation of the management arrangements as well as risk control systems and workplace precautions. The *reactive systems* monitor accidents, illnesses, incidents, and other evidence of deficient health and safety performance.

Diekemper & Spartz (1970) have made a similar distinction between these two types of measuring systems. According to them, active systems are such which measure the quality and quantity of the *safety activities*. Accordingly, reactive systems are such which measure the *results* or *performance*.

According to HSE, the various forms and levels of active monitoring include:

- routine procedures to monitor specific objectives, e.g. by quarterly or monthly reports,
- periodic examination of documents in order to check that systems promoting health and safety have been established (e.g. documents where the objectives of each manager have been defined,
- the systematic inspection of premises, plant and equipment by the various persons in the supervisor, line-management, and employee level,
- environmental control and health surveillance in order to check the health control measures,
- direct observation of the work and behavior by the supervisors,
- the operation of the audit system,
- follow-up of health and safety reports by the top management.

Reactive systems are started after the event has taken place, and they include identifying and reporting of (Successful ... 1997):

- injuries and cases of occupational illness, including the monitoring of sickness absence records,
- other losses, such as damage to property,
- incidents, including those with the potential to cause injury, illness or loss,
- hazards,
- weaknesses or omissions in the performance standards.

3.7.3 Auditing

The ISO Standard 10011-1 (1990) defines *audit* as a systematic and independent examination to determine whether the company's activities comply with planned arrangements and whether these arrangements are implemented effectively and are suitable to achieve the objectives.

According to HSE (Successful ... 1997), a *health and safety audit* is a structured process of collecting independent information on the efficiency, effectiveness and reliability of the total health and safety management system, and drawing up plans for corrective actions. Furthermore, auditing supports monitoring by providing managers with information on how effectively plans and the components of the health and safety management system are implemented. In addition to this, an audit should provide a check on the adequacy and effectiveness of the management arrangements, and risk control systems.

Audits can be used in many different situations. An *initial* safety audit is the basis for the establishment of a safety policy and safety program. In BS 8800 (1996) this activity is called an initial status review. Similarly, a *periodic* safety audit is an examination to verify the conformance with the requirements set in the safety policy and safety program.

3.7.4 Reviewing performance

Reviewing is a top management activity. It should be a process of making judgments about the adequacy of the performance and taking decisions about the actions necessary to eliminate the deficiencies. Reviewing should have effect on the organization’s safety policy and strategic goals (Cooper 1998).

The information for the review comes mainly from the measuring system and from the audits (BS 8800 1996). The measuring system brings information on the safety outcomes, and the audits give information on how well the pre-defined safety activities have been carried out and whether any problems have been noticed.

4. Safety auditing

4.1 From authority control to internal auditing

Safety legislation has existed for hundreds of years. In 1273 the sale of sea coal was banned in the United Kingdom due to its polluting emissions. The world's first Factory Inspectorate was established in 1833, also in the UK. Organized authority control of occupational safety was developed in the beginning of the 20th century when the first workmen's compensation laws were introduced. The first legislation developed mainly on an *ad hoc* basis as hazards were identified. (Fairman 1999)

In August 1971, the Occupational Safety and Health Act came into being in the USA. At the same time, the Occupational Health and Safety Administration (OSHA) was established. The first safety programs that OSHA promoted consisted mainly of inspections. Enforcement was used as the primary method to pursue employers to reach the minimum compliance (Eckhardt 1995).

The OSHA soon realized that the enforcement approach was not adequate. It was found that besides equipment, also people's unsafe behavior contribute to accidents. As a result of this, since the mid-1980s OSHA has concentrated on programs that promote besides the correction of unsafe conditions also unsafe human acts (Ferry 1990).

In Europe, the development of safety control systems has been similar to the USA. Until early 1980s, safety at work was promoted mainly by legal requirements. The safety authority's main tasks was to pursue detailed safety investigations at workplaces. Already in 1970s, some European countries introduced occupational health care legislation which included regular on-site work analyses. In 1989, the "framework" Directive 89/391/EEC of the European Union obligated the employer to prepare a safety program which describes how the health and safety effects of the work environment are controlled. This Directive is now adopted to national legislation in the EU Member States.

Both in the USA and in Europe, the 1990s was the decade when standardized safety management systems were introduced on a large scale. At the same time, the focus has changed from the authority control to internal hazard control. The role of safety authority is changing from an inspector to an advisor who participates in the development of company's safety activities (Virkkunen 1996, Roughton & Grabiak 1996).

The OSHA's Voluntary Protection Program (VPP) is an example of an attempt to support safety management systems that go beyond the legal standards. VPP is program to which company has to apply. When the application has been submitted, OSHA schedules an on-site review to evaluate whether the company meets the VPP criteria, and can participate in the program. (So ... 1997).

Auditing has a clear role in the development of a company's internal hazard control systems. Internal auditing is one method to show authorities that the company's safety efforts are adequate and effective. Besides this, auditing is an effective method for finding those safety activities that require improvements. Management reviews are one of the central procedures where the audit results are evaluated, and where new activities and safety goals are determined (cf. Section 3.7.4).

In certain conditions, the safety authority can act as an external safety auditor. For example, the Health and Safety Executive (HSE) in the UK (Successful ... 1997), and the Belgian Labor Inspectorate (Gils 1994) have established special authority audit systems. They also advise companies on how to develop and run an effective safety management system. Safety authority audits can be seen beneficial also because authorities probably know the legal requirements better than anyone else.

4.2 Theoretical basis of auditing

Auditing is a typical *organizational assessment* activity. An organizational assessment is a process of measuring the effectiveness of the organization from the behavioral or social-system perspective. (Lawler et al. 1980a)

A comprehensive organizational assessment has three elements: 1) the organization to be assessed, and the people working there, 2) the assessment team, and the theories and measurement tools used for the collection of information, and 3) the people who receive and use the results of the assessment, and who generally provide the resources for conducting the proposed activities. The key measurement areas of an organizational assessment are: tasks, individuals, groups, formal organizational arrangements, informal organization, surrounding environment, and the outputs of the behavioral system. (Lawler et al. 1980a)

According to Cooper (1998), any management system audit should be able to identify, assess, and evaluate the organization’s problems so that recommendations for improvements can be made. However, an audit cannot solve all problems. Cooper points out that although an audit may be able to identify the most serious problems, it cannot possible identify every existing problem no matter what type of audit is used, and what the audit’s focus (e.g. quality, safety, environment) might be.

Some standards give general guidelines for planning and executing an audit. For example, the ISO 10011-1 (1990) standard states that the objectives of a quality audit are:

- to determine the conformity or non-conformity of the quality system elements with specified requirements,
- to determine the effectiveness of the implemented quality system in meeting the specified objectives,
- to provide the auditor with an opportunity to improve the quality system,
- to ensure that the regulatory requirements are met,
- to permit the listing of the audited organization’s quality system in a register.

Certification of safety management systems is not so common as certification of quality management systems. However, this situation is changing, since companies can now “commit themselves” to the Responsible Care program (CEFIC ... 1996), and Det Norske Veritas and some other third party organizations are now certifying also safety management systems.

4.3 Types of safety audits

Safety auditing has many definitions. Some people use a very broad definition, implying that the scope of safety auditing includes virtually all safety management activities, while others have adopted more focused technical approaches. The following categorization of Glendon (1995) clarifies the types of safety audits:

1. Safety audits on *specific topics*, for example, human factors or hazardous substances.
2. *Plant technical audits* involving a review of the plant processes, and done by specialist staff.
3. The *site technical audit* covering special work tasks, and done by both local and special staff.
4. *Compliance audits* (or *verification audits*) to establish whether the relevant legal requirements are met.
5. *Validation audits* which deal with the scope and design of the audit. They focus, for example, on whether the right kinds of subsystems have been adopted, and whether the correct types of monitoring methods are in use. Together, validation and verification audits comprise the management safety audit.
6. The *management safety audit* (or *area safety audit*) which covers general safety matters, and involves local staff and perhaps specialist auditing staff as well.

Glendon's types 1-3 are more like hazard management activities or risk analyses which were described in Section 3.6. In the following sections, the term safety auditing refers to Glendon's type 6, i.e. *management safety audit* type of activities.

4.4 Safety audit procedures

4.4.1 Reliability of the auditor

A safety audit can be performed either "internally" where the company's own personnel reviews the performance, or "externally" where the assessment is done by a trained expert from outside the organization. Clerinx & Langenbergh (1994) point out that a danger of internal safety audits is that the effort is made only for the judgment, and not to increase the level of health and safety. In the long term, this can harm the improvement and continuing effort activities.

Byrom (1994) from HSE points out that the audit team members and the leader should be independent of the area being audited and should have the necessary combination of experience and knowledge. Similarly, the ISO 10011-1 (1990) standard mentions that auditors should be free from bias and influences which could affect objectivity. Finally, Glendon et al. (1992) have found that careful selection of the audit team is an essential contributor to successful results.

The audits conducted by different auditors should reach similar results when the same operation is audited under the same conditions. Good consistency means that there is no bias between the auditors. Consistency among auditors can be improved, for example, by arranging auditor training, auditor performance comparisons, reviews of audit reports, performance appraisals, and rotation of auditors between audit teams (ISO 10011-3 1991).

4.4.2 Audit techniques

Three stages can be distinguished from an audit process: 1) preparation, 2) on-site activity, and 3) follow-up. The steps that are typically included in each of these stages are illustrated in Figure 7. The size of a company, branch of activity, the type of hazards, etc. determine how detailed each step is taken. The activities in the different stages and steps are discussed in the following paragraphs as described by Steen (1996), Byrom (1994), and Cooper (1998), and in Guidelines for ... (1993).

THE PREPARATION

The preparation of an audit is dependent on the size and complexity of the organization, the range and nature of the hazards and risks to be controlled, and the effectiveness of the existing safety and health management system. It includes the determination on the scope of the audit, for example will it cover the whole safety and health management system or only parts of it. The scope also influences on the size and composition of the audit team. Information on the organization’s structure and the key people in it should be available. Questions need to be prepared in order to improve the understanding of the management system, documentation, etc. An exploratory visit to the site is often beneficial.

ON-SITE ACTIVITY

An opening meeting is normally the first activity when the audit team arrives the site. In this meeting, the key persons of the unit to be audited have the opportunity to meet the auditors, and the auditors can explain their objectives, approach, and the overall audit process.

The on-site process can be divided into the following steps (Guidelines for ... 1993): 1) understanding the management system, 2) assessing the strengths and weaknesses, 3) gathering the audit data, 4) evaluating the data, and 5) reporting the audit findings.

The first step includes developing an understanding of the company's processes, internal management and technical controls, the hierarchical organization, staff responsibilities, compliance parameters, and any current or past problems.

The purpose of the second step is to help determine the focus of the audit. Where the internal controls are found to be sufficient, the auditor can concentrate on determining whether the control systems function effectively on a constant basis. On the other hand, if the internal system is inadequate to ensure the desired results, the system itself should be examined more carefully.

In step three, the audit data is collected by interviewing, observing, and verifying. The interview process starts usually from the top management and continues progressively to lower levels. Observation should include both the physical premises and the employee behavior, including the work methods and possible risk taking. Verification includes examination of the records and other relevant documents.

In the fourth step, the gathered data are evaluated to identify the audit findings. The findings are reviewed against the safety management system criteria to determine their significance. A negative finding is called nonconformity.

In the final step, the audit team holds an exit meeting, where the management should have an initial view of the audit team's findings. Both positive and negative findings should be presented, and any ambiguities about the findings should be clarified.

CONCLUSIONS

When the on-site work is complete, the audit team should begin the preparation of the audit report. A normal practice is that the audit team first prepares a draft report, has the report reviewed, and then issues the final report. The purpose of the review is to assure that the report is clear, concise and accurate, rather than to modify the audit team's findings. The audited facility should prepare an action plan immediately after the submission of the final report. The action plan should indicate what is to be done, who is responsible for doing it, and when it is to be completed. Often the auditor receives a copy of the action plan. Sometimes the auditor is asked to review the plan to ensure the aims are what the auditor had intended, and in some cases the auditor also monitors the completion of the plan. Whatever the procedure is, it must be remembered that it is always the responsibility of the operating management, and not the auditors, to write and implement the action plan.

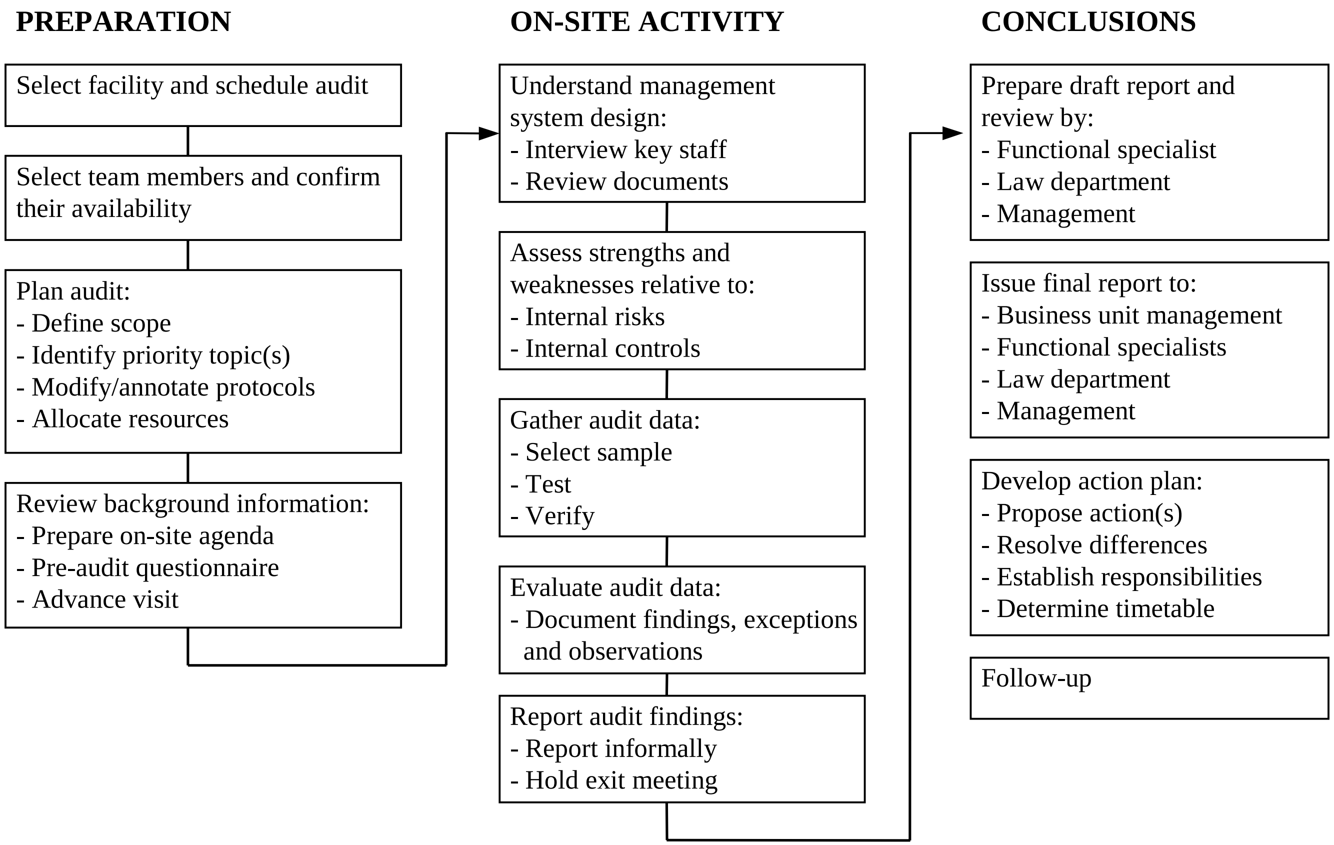

Figure 7. The three stages of an audit process. Adopted from Guidelines for ... (1993).

4.5 Management safety audit tools

4.5.1 Overview

Checklists were the first tools developed for assessing safety management systems. These were followed by simple yes-no type audit methods, and the next step was the creation of complicated quantified audit tools. (Petersen 1989). Today, safety audit tools usually include a list of safety activities to be assessed, and the criteria for the evaluation. The activities are typically grouped under headings like “organization”, “risk control” or “reporting”. Safety audit tools are typically developed by health and safety authorities, by private consulting companies, or by universities and other research institutions. One of the earliest tools was developed by Diekemper & Spartz in 1970. Since then several other methods have been reported, for example ISRS (ISR 1978), CHASE (Glendon et al. 1992), SafetyMap (SafetyMap ... 1995), Self-audit handbook (1995), and VPP (So ... 1997).

Some audit tools are combined health, safety, and environmental assessment methods. The SHE-audit (1996) of the Association of Swedish Chemical Industries is an example of these methods. An example of a partial safety audit method is the Responsible Care program developed for hazard management in chemical industry (Guidance on ... 1991). All the quality award programs also assess some areas of safety management (cf. Criteria for ... 1999).

This section describes four relatively comprehensive management safety audit tools. One of them is a general purpose safety audit method, while the others are designed to be used mainly in industrial workplaces. These selected tools are from several time periods, the oldest being from 1970 and the most recent one from 1994. The reason why the old ones are included is that they are widely known, and there is also some experiences reported on their use. A summary of these methods is presented in Table 4.

4.5.2 Diekemper & Spartz (D&S)

The D&S method was developed for measuring the nature and level of the efforts applied to the control of industrial accidents (Diekemper & Spartz 1970, Petersen 1989). The method consists of three parts: 1) the activity standards, 2) a rating form, and 3) the summary sheet to calculate the final activity score. Each activity is rated on a four-level scale (poor, fair, good, excellent), and a list of criteria is provided for each level.

The developers of the method stress that D&S is a measurement of “activity”, rather than a measure of “results” or “performance”. This is because the level and nature of activities cannot always be translated into commensurate results. Furthermore, safety results, as expressed in both severity and frequency rates, can often be “explained away” or the results can even be controlled to some extent.

The developers of D&S see that it is possible to create an objective method to measure both the quality and quantity of safety activities, and which also determines how well hazards are controlled. Such a method should fulfill the following three criteria: 1) the measurement device must be standardized, 2) the observed activity must be structured so that it can be measured, and 3) the measurement technique must be designed so that the line-managers can personally relate their activities to the standard. (Diekemper & Spartz 1970).

The D&S method has been used in at least two reported case studies. A modified version of the method has been developed by Uusitalo & Mattila (1990), and then used in small and medium-sized industrial companies (Kakriainen et al. 1992). The reliability or validity of the method was, however, not evaluated in these studies. Another study where also the validity of the method was estimated was carried out by Uusitalo & Mattila (1989) in eleven industrial companies. In this study, a fair correlation was found between the audit ratings and company’s accident rate.

4.5.3 Complete Health and Safety Evaluation (CHASE)

CHASE is a method developed in Great Britain together with contributors from industry, universities, and health and safety authorities. The smaller version, CHASE-I, is for small and medium sized organizations, while CHASE-II is for large organizations having 100 employees or more. (CHASE I 1989, CHASE II 1989)

CHASE is comprised of 12 sections (CHASE-II) or 4 sections (CHASE-I). Each of the sections include a number of short questions. Answering “yes” gives 2-6 points depending on the activity assessed, and answering “no” gives zero points. Some questions can be skipped if they are not relevant in the company, for example if chemicals are not used or stored on-site. The scores can be calculated to each section, and to the overall activity. CHASE includes some guidance for the auditor, for example definitions, clarification, and a list of relevant legislation.

During the development of CHASE-II, the method was tested in the transport industry where the audits were carried out in nine locations in 1990. The follow-up audits were conducted a year later. Improvements were registered in all of the 12 sections of CHASE-II as a result of the work carried out in the period between the two audits. A summary of audit scores was also produced for each site, showing a range from 18 % to 70 % (average 52 %). (Glendon et al. 1992)

4.5.4 International Safety Rating System (ISRS)

ISRS is an audit method first introduced in 1978 by the South African Chamber of Mines. Today, ISRS is a property of DNV, and widely used throughout the world. ISRS comprises of a number of short questions to which the auditor answers “yes” or “no”. These questions are grouped into 20 elements of the method. From the answers to the questions the score of each individual element or the total activity level can be calculated. (ISR 1978, Guastello 1993)

The validity of ISRS has been tested in several studies. Pringle & Brown (1989) have reported a 12 % drop in accident rates among 2395 North American companies who used ISRS during the period 1978-1979. In another study, among South African gold mines, no significant correlation between ISRS rating and accident outcomes was found (Eisner & Leger 1988). Also, Guastello (1991) has come to the conclusion that there remains little support for the claim that the ISRS is an effective means of accident control. Guastello points out, however, that a useful effect of the ISRS method could have appeared if a more sensitive statistic would have been available.

Bartholome (1994) has reported experiences in the use of the ISRS in large chemical plants. According to him, to succeed in the application of ISRS, it is necessary to do the following: respect local site culture, reserve time to comments and discussion, support local management efforts, involve as many managers as feasible in the audit, and avoid routine in the audit process. Furthermore, Bartholome suggests that some aspects of safety management, namely management of change, emergency response, and hazards analysis, require some development in the ISRS method.

4.5.5 Safety Management Achievement Program (SafetyMap)

SafetyMap was developed by the Health and Safety Organization, Victoria (Australia). It was first published in 1994, and revised in 1995. SafetyMap provides a framework upon which an organization can build its own health and safety management system. Since SafetyMap is a quite recent development, no validity or reliability studies were found on the use of the method.

SafetyMap includes a feature called *Achievement Certification*. This three-level certification scheme is based on the audit results achieved by the company. The three levels are: 1) initial level, 2) transition level, and 3) advanced level. At the *initial level*, the company meets approximately one third of the audit criteria. In practice, this means that the basic legislative requirements are met, and there is a basis for an integrated health and safety management system. At the *transition level*, approximately two thirds of the criteria are satisfied. To meet this level, the company should have a well-developed safety culture, and significant safety results should be achieved. Finally, at the *advanced level*, all audit criteria should be in place, and the organization should be operating at best practice gaining maximum benefit from the health and safety management system. The company can obtain the *Achievement Certificate* by submitting the organization’s health and safety management system to an independent audit. The certificate itself is awarded (in Australia) by the Health and Safety Organization. (SafetyMap ... 1995)

Table 4. The purpose, scope and contents of four management safety audit methods.

Method name	Diekemper & Spartz (D&S)	Complete Health and Safety Evaluation (CHASE)
Purpose, scope	D&S was developed in the USA in 1970 to measure the quality and quantity of safety activities in industrial companies.	CHASE is a general management health and safety audit method for general industry. There are two versions of CHASE, one for large organizations and another for small and medium-sized organizations.
Contents	D&S addresses the following activity areas: 1. organization and administration 2. industrial hazard control 3. fire control and industrial hygiene 4. supervisory participation, motivation and training 5. accident investigation, statistics and reporting procedures	CHASE-II for large organizations includes 12 sections, which include the management of: 1. legal requirements and resources 2. tools, equipment, fixtures and fittings 3. machinery and plant 4. chemicals and substances 5. vehicles 6. energy 7. health 8. tasks 9. people 10. monitoring and feedback 11. change 12. emergencies and special cases CHASE-I for small and medium sized organizations has the following management focused sections: 1. organizational aspects of health and safety 2. physical aspects of the environment 3. chemical hazards and other health issues 4. less common risks

Table 4... continued.

Method name	International Safety Rating System (ISRS)	Safety Management Achievement Program (SafetyMap)
Purpose, scope	ISRS is a safety audit program designed to be conducted by managers of industrial workplaces. Managers are trained as auditors who assess the workplace on an annual basis. In addition, specially certified ISRS personnel can be called upon to conduct the audit.	SafetyMap is a method to be used internally by organization's own personnel. The use of the method is not limited to industrial companies. SafetyMap system is planned for organizations of all sizes.
Contents	ISRS consists of the following elements: 1. organization and administration 2. planned inspections 3. accident investigation 4. organizational rules and regulations 5. employee training 6. personal protective equipment 7. health control and services 8. records and reports 9. management training 10. accident/incident analysis 11. emergency preparedness 12. job analysis and procedures 13. group meetings 14. hiring and placement 15. purchasing and engineering controls 16. program evaluation system 17. personal communications 18. general promotion 19. off-the-job safety 20. reference library	SafetyMap consists of the following elements: 1. building and sustaining commitment 2. document strategy 3. design and contract review 4. document control 5. purchasing 6. working safely by system 7. monitoring standards 8. reporting and correcting deficiencies 9. management movement and materials 10. collecting and using data 11. reviewing management systems 12. developing skills and competencies

4.5.6 Comparison of the weights to different activities

In D&S, CHASE-II, and ISRS weighted values are used for giving more importance to some activities than others. In Table 5, the safety activities assessed in the D&S, CHASE-II, and ISRS are divided into four categories A, B, C and D. This division was done in order to clarify how much weight each of these three audit methods put to these categories. The division cannot be accurate, but it gives an idea of which activities are seen important in each method.

Table 5. The percentage of weight given in the D&S, CHASE-II, and ISRS to ifferent categories.

Category	D&S	CHASE-II	ISRS
A. Policy, organization, and administration	20	35	33
B. Hazard control and risk analysis	40	48	19
C. Motivation, leadership, and training	20	6	19
D. Monitoring, statistics, and reporting	20	11	29
Total (%)	100	100	100

4.5.7 Summary of the current management safety audit methods

All the audit methods presented in Sections 4.5.2-4.5.5 measure both the quality and quantity of safety activities. Three of the methods give weights to each assessed activity. However, no specifications was possible to find on how the weights were determined. Diekemper & Spartz (1970) state that the weighted values of D&S method are not permanent, and they should be reviewed and changed to reflect progress.

Table 5 in Section 4.5.6 shows that the oldest method (D&S) gives little weight to the policy, organization and administration, and a lot of emphasis is put to hazard control activities. The more current methods, CHASE and ISRS have increased the importance of management activities. For some reason, CHASE gives little value to behavioral safety, e.g. to safety leadership and worker motivation to safe work practices. Both D&S and ISRS give more weight to these activities. Finally, ISRS puts a lot of emphasis to follow-up of safety results. It can be concluded that the older audit tools emphasize the risk analysis and other hazard control activities, while the modern methods give more weight to safety policy, organization and administration, and follow-up.

Reasonably thorough scientific validity studies have been carried out only with the ISRS method. In all of these studies, accident records were used as a reference. The results of the validity studies have been conflicting. Some studies showed decrease in accident rate among ISRS users, and some studies showed no correlation at all. On the other hand, validity studies with safety audit methods are difficult to carry out, since accidents do not necessarily correlate with safety activities. Finding the correlation would at least need testing in a considerable number of large-scale companies, and a long time period for the follow-up. In low accident-frequency companies accident rates can be totally useless in validity considerations. However, validity studies are important, since it is crucial to know whether the safety activities that are measured really have effect on the company's safety results.

According to the author's own experience, the D&S method can be used by an experienced safety professional without special training. CHASE is a method that requires a quite thorough understanding of occupational health and safety management systems. Thus, it is probable that the successful use of CHASE requires a trained and experienced safety expert. ISRS is clearly a method to be used only by specialized personnel trained in the use of the method. Finally, SafetyMap is (according to the SafetyMap manual) a "do-it-yourself" package. However, since SafetyMap only includes very little guidance on the use of the method, it can be assumed that a very skilled auditor is required.

The use of CHASE is supported by computer software. Information on whether the other three audit methods have any software support was not available. However, since auditing a large organization produces a lot of information, computerized safety audit systems are likely to be the only sensible way of handling safety audit data (Glendon et al. 1992).

4.6 Summary

Auditing is a relatively new methodology in the field of health and safety. This is one reason why safety audit practices are still under intensive development. It is obvious that some quality auditing practices can be applied to safety auditing. However, it seems that quality audit practices cannot be directly applied into safety audits. This is, above all, because a safety audit includes the compliance assessment, that is, evaluation whether the relevant legal requirements are met. Most quality audits do not have this aspect. The requirement for compliance evaluation also means that in safety audits, the auditor's knowledge on relevant legislation has to be sufficient.

Most of the current safety audit methods are developed for industrial companies. Whether these methods are suitable for other sectors, is not known. In general, the validity of audit methods is unclear. Among the methods presented in Section 4.5, ISRS is the only one which is at present in large use, and which has been validated to some extent.

An audit method where the activities to be assessed, and the criteria used for the determination are fixed, may lead to a situation where all the requirements seem to be fulfilled and no room for improvement would appear (Eisner & Leger 1988). This can also be a problem with the methods described in Section 4.5. This situation can be avoided if the audit method has either space for new requirements or there is a possibility to tighten the criteria. The weak point with criteria that are open to interpretations is that the results may have more bias, that is, they become less reliable.

The safety audit methods described in Section 4.5. focus on the management of accident hazards that can lead to an injury. Behavioral safety, that is, the management of personnel through leadership and motivation is not touched upon to same extent. Also, evaluation of the supervisor's and line management's abilities to resolve mental and social problems, has almost entirely been omitted in these methods.

5. Materials and methods

5.1 Materials of the study

The material of the study consists of audit results obtained from 11 industrial companies. In Cases I-IX, the D&S audit tool was used. For the Cases X-XI, a new MISHA (Method for Industrial Safety and Health Assessment) audit tool was developed. MISHA was created based on literature surveys, expert group sessions, and the experiences gained from the first nine case studies.

5.1.1 Case studies using the D&S method

The D&S method used in the Case studies I-IX was originally presented by Diekemper & Spartz (1970). In this study, the method was slightly modified in order to make it better meet today's legal and other requirements. The reason for choosing this method was that it addresses all the key areas of industrial health and safety management. Furthermore, Heinrich et al. (1980) have described the method as an excellent device for measuring occupational health and safety activities. Also, Petersen (1989) has included the method into "Techniques of safety management" as an example of an easy-to-use audit method. An additional reason for the selection was that the author was already familiar with the D&S method. The entire D&S audit method is presented in Appendix A.

The case studies using D&S method are numbered I to IX. Studies I-VI were carried out in the United States of America (Kentucky). These studies were carried out in cooperation with the Center for Industrial Ergonomics at the University of Louisville. The Case studies VII-IX were carried out after that in Finland. The Institute of Safety Engineering at the Tampere University of Technology provided the necessary conditions for these case studies.

In Case studies I-IX, each audit included an interview with the company's safety personnel, the human resources manager and/or with the executive manager. After the interview, a short walk-through of the production plant was done. The employees were occasionally, but not systematically interviewed during the walk-through. Also, the essential safety related documents, e.g. the safety policy, the safety training manuals, and some of the written work instructions, were reviewed. The time used for each interview was approximately three hours.

In Case studies I-VI, two individual audits were carried out in each company. First, the author assessed the safety activities. After that, the company personnel which participated in the interview assessed the activities. This two-fold approach was done in order to test the inter-observer reliability of the D&S method. In Cases VII-IX, the assessment was done by the author and simultaneously by a group of students who had specialized in studying safety engineering. For the students, this assessment was the work to be done after they had completed the "Safety Management" course at the Tampere University of Technology. It can be assumed that the students were quite familiar with the principles of safety management, and health and safety related legislation. The students' assessments provided more information on the reliability of the D&S method.

In Cases I-VI, a list of the 30 activities that the D&S method addresses was sent to each company about two weeks prior to the interview. However, the scale and the criteria of the method were not shown to the company's personnel until the interview had been completed.

In the USA (Cases I-VI), all the companies were selected from the manufacturing industry. The selection was done from among companies which had previously been in cooperation with the University of Louisville. A request was sent to 16 companies from which the six case study companies were selected. In five of the companies, the number of employees was between 70 and 200. In one company, the total number of employees was 2900 (Case IV). For the Finnish studies VII-IX, the companies were selected from the southern part of the country. Two of the companies were from the manufacturing industry, and one from the industrial services branch. The number of employees in these companies was 600, 500, and 28.

The safety activities of the case study companies I-IX are presented in detail in Chapter 6. This is done in order to give the reader a thorough picture of the actual safety activities and safety performance of the companies. This also makes it possible to draw conclusions on the differences in the audit results.

Since there are results both from companies in the USA and in Finland, it was possible to compare safety practices and safety cultures between these two countries. This comparison is done in Section 6.5.

5.1.2 Case studies using the new MISHA audit method

The new audit method – MISHA – was developed on the basis of the knowledge acquired from literature surveys and from the Case studies I-IX. During the development of MISHA, comments and criticism were obtained from several colleagues working at the Tampere University of Technology and the Finnish Institute of Occupational Health. In addition to this, several individuals from the participating companies contributed to the contents and structure of MISHA. The development and the structure of the method are presented in Chapter 7. The results of the tests in two companies are described in Chapter 8.

The MISHA method was developed and tested in two phases. The first version was tested in a metal products manufacturing company. The test results indicated inadequate inter-observer reliability, and thus it was decided that a second, improved version was needed. The second version was then tested in a plastic products manufacturing company.

The results obtained in the audit process were discussed with the personnel of each company. In these discussions the results were examined, and the validity and reliability of the audit method was considered.

5.2 Research methods

5.2.1 The strengths and weaknesses of the case study technique

Case study technique typically includes data collection from the real world using methods like questionnaires, interviews, observations, and document reviews. The close connection with empirical reality usually improves the theory and makes it testable, relevant and valid.

It can be argued that in some cases the theories built on the basis of case studies only strengthen the investigator's preconceptions. According to Eisenhardt (1989) it is just the opposite. The constant juxtaposition of conflicting realities "unfreezes" thinking, and so the results have the potential to include less bias than a theory built from "armchair" conclusions. Furthermore, a case study approach usually produces a theory that is likely to be testable with constructs that can be easily measured. This is because the theory has already undergone several verification rounds during the theory-building process. In contrast, a theory which is generated apart from direct evidence may have testability problems. Thus, a case technique will more probably result in a theory that is likely to be empirically valid, and where the results mirror reality quite closely.

The use of a case study technique has also several weaknesses. Firstly, scientists working with voluminous amounts of data may lose their sense of what are the most important relationships in the particular case. Secondly, case studies may lead in a narrow theory which cannot be applied at a general level. These kind of theories usually only remain as descriptions of specific phenomena. (Eisenhardt 1989)

The material of this work was mainly collected using a case study approach. The data was collected using typical case study techniques like interviews, observations, and document reviews. Furthermore, the new MISHA health and safety audit method is a result of several development steps including theory building, literature surveys, discussions with experts, as well as reliability testing. Thus, it can be assumed that the main weaknesses of a case study technique have been avoided in this work.

5.2.2 Interviews as an organizational assessment method

The most direct way of assessing how an organization functions is to ask the people who work there. The members of an organization can be a valuable source of data, both about how the organization functions and how people feel it. Interviews are particularly useful during the early stages of an organizational assessment when the observer is learning about the organization and the people in it. Interviews also have some potential problems as a data-collection method. Firstly, they are expensive since they require a lot of interviewer's and respondent's time. Secondly, the interviewer can bias the responses by the choices of what questions to ask, and by the nature of the interactions with the respondent. (Lawler et al. 1980b)

There are basically three types of interviews: 1) *unstructured interviews*, 2) *structured open-ended interviews*, and 3) *structured fixed-response interviews*. Lawler et al. (1980b) have presented the strengths and weaknesses of interviews in organizational assessments as follows:

In an *unstructured interview*, the interviewer provides only minimal guidance. The interview can thus move in any number of different directions. The data from these are often voluminous and difficult to code quantitatively. They are also open to all kinds of bias, and their statistical validity is usually indeterminable. On the other hand, they are highly flexible, and produce rich data. Unstructured interviews are most frequently used when the organization is entered for the first time.

The *structured open-ended interviews* have predetermined questions covering certain topics, but the respondent has certain freedom in answering them. This type of interview is easier to score and summarize than an unstructured interview. Furthermore, the structured nature makes it more replicable, it is less open to bias, and it can often be conducted by less well-trained interviewers. This type of interview is best used for gathering data to help explain quantitative results.

Structured fixed-response interviews not only include the questions, but also a set of predetermined alternative responses. This kind of interview is in many ways an orally administrated questionnaire which, however, permits some options. Because of the scoring system the costs are low, data are more easily stored, interviews are more replicable, and most of the bias are eliminated.

In this study, interviews were the main method for collecting data while auditing the companies. The audit method used in Case studies I-IX was different to the one used in Case studies X-XI. This is the reason why also the nature of the interviews were different. In Cases I-IX with the D&S audit method, structured fixed-response interviews were used. In Cases X-XI, where the MISHA method was used, the interviews were more like structured open-ended interviews.

5.3 Statistical methods

Handling of empirical data requires the use of various statistical methods. In the following, the reliability, validity, and significance testing methods used in this work are described.

RELIABILITY

The results of an assessment should be reproducible under different conditions. In many cases, different observers, or even the same observer at a different time, may reach different conclusions. The concept of *reliability* provides an estimate of how consistently the studied behavior is observed and scored. In addition to this, agreement between observers reflects whether the target behavior or activity is defined well enough (Kazdin 1978).

Intra-observer reliability measures the variation which occurs when one observer performs multiple judgments at different times. *Inter-observer reliability*, on the other hand, measures the variation that occurs when two or more persons make the judgments independently. Usually, both of these reliability tests should be used when the reliability of a new measurement method is evaluated. However, if it can be assumed that inter-observer reliability contains all the sources of error contributing to intra-observer reliability, plus any differences which may arise between observers, then it may be sufficient to use only inter-observer reliability tests (Streiner & Norman 1995).

Cohen (1960) has presented *Kappa* (κ) as a coefficient of agreement for nominal scales. The proportion of agreement corrected for chance is the following:

$$\kappa = \frac{p_o - p_c}{1 - p_c} \qquad (1)$$

where p_o is the observed proportion of agreement, and p_c is the proportion of agreement expected by chance. It can be seen that when the agreement equals the chance agreement, $\kappa = 0$. Greater than chance agreement leads to positive values of κ, less than chance agreement leads to negative values. The upper limit of κ is +1.00, occurring when there is perfect agreement between observers. Originally, Kappa was restricted to the case where the number of observers is two. Afterwards, Kappa has been generalized to the case where more than two observers rate each subject (Fleiss 1971).

Kappa considers only the total agreement and does not provide partial credit. This is often inappropriate for scaled responses where the responses may differ by only one or two categories. A solution to this is an extension of Kappa, called *weighted Kappa* (κ_w) (Cohen 1968), which assigns some weight also to the disagreements between observers. The formula for weighted Kappa is:

$$\kappa_w = 1.0 - \frac{\Sigma\, w_{ij} \times p_{oij}}{\Sigma\, w_{ij} \times p_{cij}} \tag{2}$$

where w is the weight assigned to the i,j cell, and p_{oij} and p_{cij} are the observed and expected proportions in the i,j cell. In principle, the weights could be assigned arbitrary values between 0 and 1. However, unless there are strong prior reasons, the most commonly used scheme, called *quadratic weights* should be used (Streiner & Norman 1995).

The relative strength of agreement associated with Kappa has been determined by Landis & Koch (1977) as follows:

Value of κ	Strength of agreement
< 0	Poor
.00 – .20	Slight
.21 – .40	Fair
.41 – .60	Moderate
.61 – .80	Substantial
.81 – 1.0	Almost perfect

According to Fleiss (1973), both Kappa and weighted Kappa can be employed as a measure of reliability for quantitative scales. Since Kappa considers only the perfect match between observers it should be used for nominal scales only, while weighted Kappa is preferable for ordered scales.

In this study, weighted Kappa with quadratic weights has been used. Reliability considerations were arranged using inter-observer reliability tests as described in Sections 5.1.1 and 5.1.2.

The *Standard deviation* (SD) describes how uniform the assessments between observers are. Thus, also SD can be considered as a measure of reliability of a method. In this work, the deviations among students' assessments in Cases VII-IX were studied using the SD computations.

VALIDITY

An observation method should measure what we think it measures. This leads to the concept of the method's or scale's validity. The validity is linked to the reliability – the higher the reliability, the higher the maximum possible validity.

There are many names used to describe the different kinds of validity, especially in the educational and psychological literature. For the need of simplicity, the concept of validity is often reduced to three general groups: *content validity*, *criterion validity*, and *construct validity*. (Downie & Heath 1970, Streiner & Norman 1995)

The higher the *content validity* of a measure, the broader are the inferences that can validly be drawn about the observed phenomena (Streiner & Norman 1995). According to Downie & Heath (1970), content validity is a non-statistical type of validity that is usually associated with achievement tests. An adequate sampling of items by the test constructor is usually enough to assure that a test has content validity.

The *criterion validity* can be defined as the correlation of a scale with some other measure of the phenomena under study. Ideally, this other measure is a standard that has been widely accepted in the field of study. (Streiner & Norman 1995)

Construct validity differs from the two other types of validity in many ways. Content and criterion validity can often be established in one or two studies while construct validation is an on-going process of learning more about the phenomenon, making new predictions, and then testing them. Thus, construct validity usually arises from larger theories and observations carried out during a long period of time. Furthermore, with construct validity, both the theory and the measure are assessed at the same time. Both a wrong theory, and a measurement method which cannot discriminate the studied object, can result in invalid conclusions. (Streiner & Norman 1995)

In this study, no specific validity studies were carried out. This was mainly due to the complexity of the studied phenomena, making it difficult to find parameters that would describe an audit method's validity reliably enough.

Criterion validity could have been studied by comparing the findings of the audit to the accident types in each of the case study company. This was, however, not feasible since accidents correlate poorly with safety activities and the overall safety level (e.g. Groeneweg 1992). Criterion validity could have been assessed also by using some other work analysis method as a reference. However, this would have required that this other method has been validated, and that it covers the scope of the audit method well enough. Also this kind of validation proved to be difficult to carry out.

Emphasis was put on improving the *construct validity* of the MISHA method by studying in detail a wide range of criteria for a healthy and safe workplace. These criteria were then incorporated into the MISHA method. An attempt to increase the construct validity was also made by studying several organizational assessment methods, and auditing procedures. All these concepts were also discussed with several experts from the Tampere University of Technology, the Finnish Institute of Occupational Health, the University of Louisville, and the VTT Technical Research Centre.

SIGNIFICANCE

The difference between two statistics can be a real difference or it can be only a chance variation. The Case studies I-IX included the analysis of the differences in safety performance between companies in the USA and Finland. In these analyses, the assumption of *normal distribution* for the sum scores was not reasonable for the collected data, and therefore the significance of the differences was evaluated using Mann-Whitney's U-test (also known as the Wilcoxon rank sum test). The calculation of Wilcoxon based *confidence intervals* would have needed the minimum of four units per group (Downie & Heath 1970). In this study, the confidence intervals were not determined since the required number of units were not available.

6. Case studies using the D&S audit method

6.1 Introduction

Case studies using the D&S method include audits carried out in nine companies. Six of the studies (Cases I-VI) were carried out in the USA, and three in Finland (Cases VII-IX). In each company, the safety activities where performance was assessed using a D&S audit method. In each of the Cases I-VI, the assessment was done independently by the author, and afterwards by the company's personnel. In Case studies VII-IX, the assessment was done simultaneously but independently by the author, and by a group of students.

The original D&S method was introduced in the USA by Diekemper & Spartz (1970). In this study, the original D&S method was modified. The following activities were added to the method: safety instructions to hazardous tasks, workplace design, measurement of the safety activities, safety organizational structure, and health care. The two activities that were present in the original method, but were left out in this context, were related to environmental protection and the investigation of property damage. Due to the changes, minor modifications were done also to the weights of the individual activities.

The modified D&S method used in this work addresses 30 activities. These are categorized into the following activity areas:

- organization and administration,
- industrial hazard control,
- fire control and industrial hygiene,
- supervisory participation, motivation and training,
- accident investigation, statistics and reporting procedures.

The activities, criteria, and weights of the D&S method are presented in Appendix A. For more information on the D&S method see also Section 4.5.

Section 6.2 presents the Case studies I-VI. It describes the companies and their safety activities, as well as the author's audit scores. Accordingly, Cases VII-IX and their results are presented in Section 6.3. The reliability and general usability of the D&S method is discussed in Section 6.4. Finally, the differences in safety activities between the companies in the USA and Finland are presented and discussed in Section 6.5.

6.2 Case studies in the USA

6.2.1 The companies in Case studies I–VI

In the USA, the safety activities of six companies was assessed. This section describes the companies' general activities, and presents the typical accidents in each company. Furthermore, the people involved in the interviews are listed. A summary of the companies' branch of activity is shown in Table 6.

Table 6. Companies audited in the USA – branch of activity.

Case number	**Company's branch of activity**
Case I	Manufacturing of food products for consumers and the food industry
Case II	Manufacturing of food products for consumers
Case III	Design and manufacturing of conveyer belt machines and systems
Case IV	Manufacturing of food products for consumers
Case V	Manufacturing of sheet metal products for household machines and automotive industry
Case VI	Manufacturing of plastic bottles and other small plastic products

THE COMPANY IN CASE I

The company in Case I manufactured peanut butter and peanut oil products for consumers and the food processing industry. This company had 100 employees in the plant. The manufacturing process operated in two shifts.

The premises where the factory operated were old, some parts of them being from the beginning of the 1900s. In the production line, the raw material – peanuts – were cleaned, roasted and split before the additional ingredients like salt, vegetable oil and sugar were added. The finished product was packed either into small consumer-size bottles, or into large containers which were shipped to the food processing industry.

The company had a part-time safety manager who also acted as the plant engineer. He had been working as a safety manager for 18 months. Besides the safety manager, also the company's vice president participated in the interview.

The main types of accidents in the company were slips, pinching of fingers, and back injuries. The company's employees were quite experienced on the work. The average age of the employees was high, many of them having worked for over 15 years in the company.

THE COMPANY IN CASE II

The company in Case II manufactured pasta products for consumers and rice products for the main company of the corporation. The company had a total of 104 hourly paid, and 24 salaried employees. The factory was operating in three shifts, although most of the personnel was only working on the day shift.

The oldest part of the factory was built in 1928. The storage of raw-materials as well as part of the rice product manufacturing was located in that part. Another part of the factory was built in 1960. Most of the present production systems, for example, the macaroni and spaghetti production, were housed there. The newest part, from 1980, contained all the new production systems as well as the storage of final products.

The company's part-time safety manager participated in the interview. He also acted as the quality manager of the company. He had been working for about three years as a safety manager.

In 1992, there were a total of 11 OSHA recordable accidents, seven of which were lost time accidents. The main type of accidents were slips, falls, and back injuries due to manual lifting.

THE COMPANY IN CASE III

The company in Case III manufactured vibrating conveyors and other vibrating machinery for various kinds of industries. The company had 101 employees, 35 of which worked in the production plant. The majority of the employees worked in the design department. Only day shift was used in the factory. The oldest part of the factory was built in 1954, and the latest enlargement of the premises was done in 1975. The company had recently started the implementation of ISO 9000 based quality management system.

The company had a part-time safety supervisor. He had worked for 30 years in personnel management, and now in addition to this, for over 10 years as a safety supervisor. The company's factory manager who had 15 years of experience, was also responsible for the company's safety program. Both the safety supervisor and the factory manager participated in the interview.

On an average, there had been six injuries or accidents per year requiring some medical care. The main types of accidents had been back injuries related to lifting tasks, and eye injuries caused by metal chips or other foreign objects.

THE COMPANY IN CASE IV

The company in Case IV manufactured food products for consumers. The factory had 2900 employees, 450 of which were salaried. The factory was operating in three shifts.

The oldest part of the plant was built in 1922, and the company moved into these premises in 1948. The production consisted of various food processing and packing activities.

The company had a safety department. The full-time safety manager working in this department was interviewed in the study. He had been working in the safety department for eight years. Due to the large size of the plant, it was only possible to visit some of the production areas during the assessment.

When compared to the statistics of the National Safety Council, the company's accident rate (LWIR) was below average. The goals which had been set for the accident rates each year, had been reached almost every year, and the number of OSHA recordable cases showed a decreasing trend. The most typical accidents were cuts in fingers, thumbs, and hands, as well as back injuries caused by lifting tasks.

THE COMPANY IN CASE V

The company in Case V manufactured sheet metal products for households and automotive industry. In addition, the company manufactured and assembled barbecue grills. The machinery consisted mainly of punch presses. The finished parts were either painted or coated with enamel. The company had 109 employees. The factory normally operated in one shift, although at the time of study some employees worked in two shifts.

Most of the manufacturing took place in the older part of the factory. This part was built in 1926. The new part of the factory was built up in 1957. The assembly of grills was done in this building. Also, some of the finished products were stored in the new building. The company had started the implementation of the Total Quality Management system 12 months before the study.

The personnel manager was conducting the company’s safety program. She had been working as a personnel manager for 14 years in this company. All that time, she had also been responsible for the company’s safety activities. In total, she had worked for 30 years in human resource operations.

The company had two safety committees, one for the employees, and one for the management. Both committees had a meeting once a month. The personnel manager was a member of both committees. During the past 10 years, there had been one to three lost time accidents per year. The accident rates had decreased dramatically, since 15 years ago there were approximately 150 lost time accidents annually. According to the personnel manager, the main reason for the positive development had been the increased management involvement, together with goal setting and effective safety incentives. Today, the main type of accidents are small lacerations, cuts to fingers, and minor foot injuries. These injuries were typically caused by sharp pieces of sheet metal left on floors.

THE COMPANY IN CASE VI

The company in Case VI manufactured plastic bottles and caps mainly for the liquor industry. The company had 70 employees in total. The factory was operating in three shifts, although most of the personnel were working only during the daytime. The factory had been operating for 11 years in total. This plant was an affiliated company, and the main company was located in another state.

The company had a part-time safety director who also was in charge of the shipping and receiving activities of the company. He had been working as a safety director for about six months, and as a member of the safety team for about five years.

At the time of the study, the company had operated for 38 months without a lost time accident. Typical accidents were minor cuts to fingers.

6.2.2 Description of the companies' safety activities

In the following, a summary of the assessments is presented categorized according to the activity areas of the D&S method. This presentation includes the activities in all of the six companies in the USA.

ORGANIZATION AND ADMINISTRATION

All the six companies had prepared a written safety policy. Only one of the companies was so large that it had established a safety department. When possible, the smaller companies used the services of the mother company's safety department, also in the preparation and maintenance of the safety policy and safety program.

Typically, the safety policy was constructed separately from the other company rules and guidelines. In one company (Case V), however, all safety related procedures were incorporated into the company's *Standard Procedures* which was part of the company's TQM program.

In four of the companies, management reviewed the accident reports. In Case I, the safety committee with management participation reviewed the reports, and in Case IV, the company's safety department reviewed the reports. Whether management actively directs the safety measures was somewhat difficult to determine. In Case I , it was mentioned that management follows the results of the safety reviews. Only in Case V it was clearly pointed out that management also directs the corrective measures. Furthermore, in those small companies where a safety department was located within the mother company, the accident and incident reports were sent there for review.

All companies argued that they had written instructions for most of the hazardous tasks, and that the instructions are updated regularly. Typically, truck driving and welding were understood as hazardous tasks. However, it was not possible to verify whether the hazardous tasks had been properly identified. In one company (Case V), it was mentioned that the supervisor is obliged to check each punch press before a new shift begins. In Case VI, the safety director pointed out that very hazardous work tasks do not exist.

It was not possible to clarify the workplace design practices very thoroughly during the assessments. However, it seemed that in most cases the modifications in the premises and in the lay-out of the plant were designed by the company itself. In one case (Case I), it was stated that modifications to the current premises and equipment are difficult to make. In this company, the ergonomics of work was mainly improved by job rotation. In Cases II, III, IV, and VI, it was stated that adjustable workplaces are designed when it is technically and financially possible. In Case IV, it was argued that “a lot of effort has been put into the ergonomics of manual work, and the improvements are done on a continuous basis”. In Case V, it was stated that comfortable work postures are possible in most cases, although some lifting tasks can cause bent back postures. In Case VI, the safety director mentioned that new machines are normally ergonomically acceptable, and equipped with adequate safety devices.

All companies except one (Case I) mentioned that responsibilities for emergency situations are well defined. However, also in Case I, the evacuation plans had been posted, and exits were well marked. Good control of tornado related hazards were mentioned in Cases II, III, and VI. Good fire control was mentioned in Cases III and VI, and good control of solvents and acids was mentioned in Case III. Furthermore, in Case III it was mentioned that the last emergency drills were carried out 2-3 years ago. The company in Case IV had prepared a handbook for emergency situations. In Case V, the emergency situation activities were included in the company’s *Standard Procedures* manual. Finally, in Case VI it was mentioned that the company’s emergency response team had 20 trained members.

In Cases IV, V, and VI, the plant safety rules were incorporated into the general factory rules, and in Cases IV and VI the persons interviewed mentioned that these rules were updated regularly. The company in Case I had not prepared written plant safety rules, but according to the company's safety manager, safe work practices were otherwise made known to the personnel. In Case III, the plant safety rules were delivered to all new employees. In the future, the safety rules were to be incorporated into the company's general work rules.

The effectiveness of the safety program and safety activities was done mainly by following up the accident frequency (Cases I, II, and VI). In Case I, it was mentioned that also the employees' feedback is taken into account in the follow-up. In Case III, monitoring of the lost-time accidents was the main method of evaluation. The review of incident reports was the main measure in Case V. In Cases II and VI, the level of housekeeping was one of the measures of effectiveness. Finally, the large-scale company in Case IV used the annual safety goals as the reference for the effectiveness.

All of the companies had assigned an expert who was responsible for promoting the health and safety activities. That person was called either a safety manager, a safety director, or a safety supervisor. In one of the companies, the personnel manager was that expert.

One or more safety committees had been established in all of the companies, except in Case III. The company in Case I, had a joint employer/employee committee with six members, and it was directed by the safety manager. This committee carried out monthly plant safety walk-throughs, and also reviewed its own activities annually. In Case II, it was mentioned that the company's safety committee arranges a special supervisor training session twice a year. In this company, also the importance of the main company's safety department was emphasized. The big company in Case IV had, besides the safety department, a joint safety committee in each manufacturing department. These committees discussed safety matters in their monthly meetings. In Case V, the company had two safety committees: one for the employees, and one for the management. Both committees had a meeting once a month. The personnel manager who was in charge of the company's safety program, was a member of both committees. These committees seemed to work quite actively, and they analyzed, for example, the safety properties of new machinery and equipment before they were ordered. In Case VI, it was mentioned that when possible, supervisors participate in the committee meetings. Furthermore, in this company the safety committee reviewed the accident and incident reports each month.

In Case III, there was no established safety committee, but employees had a semi-weekly meeting where also safety issues were discussed. This was seen as a sufficient arrangement, especially when only 35 persons worked in the production plant.

In general, it seemed that the main task of the safety manager was to direct the safety activities, and the role of the safety committee was to organize and carry out some of the safety tasks. When a company had a safety department, either internal or external to the plant, it was frequently consulted.

In Case I, the company's health care program covered, besides the employees, also their families. In this company, health hazards had recently been surveyed at the plant-level by the company's medical personnel. In Cases I and III, the company carried out annual hearing tests to those exposed to noise. In Cases II-V, it was mentioned that all employees go through a pre-employment physical health survey before they can begin to work. In Case IV, respiration tests were done, and repeated on an annual basis. The company's medical doctor was consulted in occupational injury investigations in Cases II and III. The company in Case II had a fitness center which was frequently used by the personnel. In Case III, it was mentioned that the health care personnel helps in the repositioning of an employee, for example in case an allergy has been found. In Case IV, the company's nurse is a member of the company's ergonomics team. This teams holds a meeting once a month. In Case VI, the health care services were obtained from the local hospital. It this case, it was also stated that there had been no need for the medical personnel to visit the plant, since no health problems had occurred.

INDUSTRIAL HAZARD CONTROL

In the assessments, the level of housekeeping was mainly evaluated visually during the walk-throughs of the plant. In all companies, housekeeping was at a quite high level. The storage of materials was well done, and the walking and working surfaces were mainly clean and free. In Case III, the employees set aside some time each day solely for cleaning their work area. In Case V, it was mentioned that the company's bonus system for promoting accident-free production had improved housekeeping.

In all the companies, the machine guards were in place, and hazards seemed to be in control. In Case V, it was mentioned that it was the supervisor’s duty to check that all safety equipment are operating properly. Sometimes, additional safety device were built on-site when the current equipment were not sufficient (Case VI).

Other hazards, besides those caused by the machines, also seemed to be under control. It was not possible to visually detect any obvious negligence in safety. In most cases, it was argued that the work environment’s safety aspects were also considered in the workplace design. How this was done in practice was not possible to clarify.

All the companies were satisfied with their maintenance system. The auditor evaluated the level of maintenance mainly by checking whether the tools and equipment were in a safe condition. In Cases I, III, IV, and V, a computerized preventive maintenance program was in use. In Case V, the program included, e.g. the annual changing of all light bulbs. In Case III, it was mentioned that an outside contractor is responsible for the maintenance of the cranes.

There were very few manual material handling tasks in the companies. Only in Case III, due to the customized nature of the production, some heavy manual material handling tasks had remained. However, also in Case III, cranes were used for the material transportation whenever possible. In Cases III and VI, it was mentioned that the maximum weight to be lifted does not exceed 25 kilograms. In Case II, the person interviewed said that the maximum weight to be lifted is 10 kilograms. In Case I, most of the products were transported using trucks. In one company (Case IV), the manually pulled carriages used for transporting the packaging materials were the most heavy equipment used.

All companies claimed that they provided adequate personal protective equipment to their employees. Furthermore, they all said that the maintenance of these equipment is well arranged. Typical safety equipment included safety glasses, ear plugs, gloves, and safety shoes. One of the companies (Case IV) had equipped all its employees with a safety lock for securing machines against accidental start. During the walk-throughs, it was not possible to detect any obvious negligence in the use of the personal protective equipment in any of the plants.

FIRE CONTROL AND INDUSTRIAL HYGIENE

All the persons interviewed claimed that chemical hazards are in control. In Case I, the MSDSs were available in the safety manager's office. In Cases II and IV they were located in the place where the chemicals are used, and in Case V the MSDSs were posted in several places around the work area. None of the companies used large amounts of hazardous chemicals. The company in Case III used some paints which were stored in a separate building, and in Case VI it was mentioned that the maintenance personnel uses some quantities of toluene.

Most of the companies had no flammable or explosive materials in use or in storage. The safety manager of the large-scale company (Case IV) announced that the storage of flammable materials was done according to the fire regulations.

Ventilation was not a problem in any of the locations. In Case I, vegetable oil fumes sometimes existed in the air, but that was not considered to be a health problem. The company in Case II had installed dust collectors to the most dusty areas. The air quality in the big company (Case IV) was measured by the industrial hygiene department that was located at another production plant. In Case VI, the safety director said the ventilation sometimes caused negative air pressure in the production area, but otherwise the ventilation equipment were well selected and maintained.

Skin-irritating liquids or other materials were rarely used in any of the companies. Employees were provided with adequate protective equipment. Injury records indicated good control of irritating substances.

Most of the companies were well prepared for fire hazards. All of the companies announced that they had sprinklers installed in all the fire hazardous areas, and that there were adequate number of fire extinguishers available. In Case I, some of the employees were trained in using fire extinguishers. In Case III, the company had no work permit system for those who did welding or other fire hazardous jobs. However, this company had only 35 employees on the production plant, and it was claimed they are well aware of the necessary precautions. In Case IV, only those persons who had attended the company's fire course were allowed to do fire hazardous jobs. Furthermore, it was stated that in emergency situations the fire crew of the company was responsible for fire fighting until the city fire department arrives. In the company of Case V, the plant emergency organization had a meeting once a month. This company also had plant guards who made hourly inspection tours 24 hours a day. Furthermore, this company had fire extinguishers installed in all locations. The company in Case VI announced that its emergency response team was trained for fire hazardous situations.

SUPERVISORY PARTICIPATION, MOTIVATION, AND TRAINING

There were several levels of supervisor safety training in the companies. In Case I, the supervisors had received some safety training, although not systematically. However, in this company two of the supervisors participated in the safety committee meetings, and also in the monthly safety walk-throughs. In Case II, all the supervisors participated in regular safety walk-throughs. Furthermore, the twice-a-year arranged training for the supervisors by the safety committee, was seen useful. The company in Case III had arranged a safety seminar for all its supervisors a few years ago. The supervisors had also received Red Cross first-aid training. In Case IV, the company provided all supervisors with continuous internal safety training. In Case V, all supervisors participated in the plant safety walk-throughs, and some of them also participated in the safety committee meetings. The supervisors in Case VI had received no systematic safety training. According to the safety director interviewed, the supervisors’ awareness and knowledge on safety had increased gradually during the years, and was at a reasonably high level at that moment. In addition to this, supervisors participated in safety committee meetings when possible.

In most cases, new employees were trained by senior workers. In Case IV, all newcomers received a one-day safety training. In this company, new employees also had to pass an exam to show they had understood the safety information presented in the given material and training. In Cases I and II, the training was mainly verbal, while special safety handouts were used in Cases III and V. In Case VI, the safety instructions were included in the general written work rules.

The concept of a *job hazard analysis* was comprehended in many different ways by the persons interviewed. For example, some companies understood it as a detailed examination of a job’s health and accident hazards, while some understood it as something that is done visually during the regular safety walk-throughs. Thus, the results are perhaps not as comparable to each other for this activity as for the others. In Case I, the health hazards of the workplace were recently analyzed by the company's medical personnel. In addition to this, potential accident hazards were reviewed during the regular safety walk-throughs. In Case II, the job hazard analyses were done, but it was not possible to clarify to what extent. The company in Case III announced that special job hazard analyses have not been done, but the identified hazards were discussed in semi-weekly employee meetings. In Case IV, over 1500 job analyses, including safety aspects, had been carried out. The company in Case V announced that job hazard analyses had been done for the majority of hazardous tasks. In Case VI, it was argued that no specifically hazardous tasks exist on the plant.

Training for specialized operations was given in all companies. However, it was not possible to detail whether the companies had identified all the operations needing special attention. In most cases, truck driving and welding were seen as special, and potentially hazardous tasks. The company in Case I argued that they have very few activities requiring special training. In Cases II, III, IV, and VI, training was given for truck driving. In Case IV, the truck drivers also had to pass a special physical test before receiving the driving permit. In Case V, it was mentioned that external assistance is used in the training when needed.

Internal self-inspections consisted mainly of safety walk-throughs carried out by the safety committee. In Cases I and V, it was mentioned that the management follows the results of these surveys. In Case III, the safety walk-throughs were done on a quarterly basis by the supervisor together with the factory manager. The company in Case IV announced that regular inspections are done in every department by the supervisor in charge, together with a member from the safety department.

In most of the companies, posters and films were used for promoting safety. In Cases I and VI, it was mentioned that written material is also used. In Case I, some of the material was mailed to the employee's home. The company in Case III announced that the accident statistics are posted on wall-boards. Some of the companies had used safety incentives like safety contests (Case III) or safety rewards (Cases V and VI).

Safety communication between the supervisor and the employees seemed to be difficult to measure without interviewing the supervisors and employees themselves. The persons interviewed had the idea that the communication was more or less irregular, but it was effective enough. In Case III, it was stated that the communication takes place mainly during the safety inspections. In Case V, it was announced that safety issues were discussed during the monthly departmental meetings. The safety director interviewed in Case VI said that safety issues are handled any time there is a need.

ACCIDENT INVESTIGATION, STATISTICS, AND REPORTING

In most cases, accident investigations were done by the supervisor together with the safety manager. According to the persons interviewed, the accident reports were normally filled using the "OSHA 200 log". The analysis was usually done within 24 hours. The report was then submitted to the safety manager and factory manager (Cases I and VI), to the safety manager and safety department (Cases II and IV), directly to the factory manager (Case III), or to the personnel manager (Case V).

All companies followed their accident rates. In the small companies, however, only a few recordable accidents took place each year and thus it was not possible to make any statistical analysis of the data. Only in Cases IV and V also statistical analyses were made. In Case I, the accident data was followed by the company's safety committee and by management. In Case II, the review was done monthly by the safety manager and the safety department. In Case III, the data was reviewed quarterly by the factory manager. In Case VI, the review was done by the safety committee.

All the companies claimed that they investigated at least some of the near-accidents. In Cases III and IV, the analysis was done using the same OSHA log as was used in case of real accidents. In Case V, the person interviewed argued that most of the near-accidents were investigated and reported.

6.2.3 Results of the Case studies I–VI

The companies obtained the highest ratings for the activity areas: *Industrial hazard control, Fire control and industrial hygiene,* and *Accident investigation, statistics and reporting*. The lowest scores were for the activity area: *Supervisory participation, motivation and training* (Table 7).

Table 7. Author's ratings for each activity area in Cases I-VI. Maximum score is 20 for each activity area. Maximum total score is 100.

Activity area	**Case I**	**Case II**	**Case III**	**Case IV**	**Case V**	**Case VI**
Organization and administration	17.2	17.6	16.2	18.2	19.0	13.6
Industrial hazard control	19.2	18.4	20.0	17.8	19.2	19.6
Fire control and industrial hygiene	15.8	19.0	18.8	20.0	19.0	20.0
Supervisory participation, motivation and training	13.6	15.2	8.2	16.0	19.6	13.6
Accident investigation, statistics and reporting	15.6	19.2	18.4	19.2	18.4	17.2
Total score	**81.4**	**89.4**	**81.6**	**91.2**	**95.2**	**84.0**

All the companies had realized the importance of safety management to the degree that they had prepared a safety policy. In most cases, this policy was a separate document. Only in Case III, the safety policy was integrated into the company's quality management system.

In Cases I and III, the safety activities were clearly directed by the factory management. In these two cases, the top management also participated in the interview. In Case I, the company put a lot of emphasis on the work environment's quality and their employees' health. This was realized by systematic workplace hazards analyses, and by employee insurance schemes which also covered the families of the workers. In Case III, the company had no safety committee, but instead the factory manager was personally committed to the health and safety activities.

The control of industrial hazards, as well as the control of fire hazards and industrial hygiene, were in all companies at a high level. On the other hand, supervisory participation, motivation and training were activities that received quite low scores. The company in Case III received the lowest scores because permits were not required for welding work, the supervisor safety training was estimated to be inadequate, job hazard analyses were not done, truck driving was the only hazardous task that included special training, and safety promotion and safety communication were only at a fair level. The company in Case III had also organized the safety activities somewhat differently to the other companies. Firstly, the safety activities were carried out mainly by the top management, and not by a separate safety organization. Secondly, only 35 employees worked in the production plant, which means that most of the safety activities were probably successfully carried out without the formal procedures required in the D&S method.

Accident investigation and follow-up of the accident statistics were at a high level in all companies. Accident rates were followed regularly, and all companies claimed they investigated at least some of the near-accidents.

There was no indication that a large corporation would automatically reach a higher rating than a small one. However, it was seen that in the large-scale company (Case IV) several safety activities were assigned considerable resources. These included excellent personal protective equipment, systematic safety training of the employees and supervisors, air quality measurements by the industrial hygiene department, systematic job hazards analyses, special physical tests for the truck drivers, and effective use of the accident statistics.

The total ratings obtained by the author were between 81.4 and 95.2, which indicates that the level of safety activities was at reasonably high level in all of the companies. According to the author’s prior experience in the use of the D&S method, ratings between 50-85 are very typical.

6.3 Case studies in Finland

6.3.1 The companies in Case studies VII–IX

The D&S method was used also in the Finnish case studies. However, one activity (A5) was different in the Finnish version. The modification meant that in Finland the employee selection and placement process was assessed, while in the USA the workplace design procedures were evaluated. The difference between these two activities can be considered minor, since both of them describe how the compatibility between the employee and designed work and workplace is ensured. The weighted values are the same in both cases. The criteria for the changed activity are presented in Appendix B.

In Finland, three companies were audited. A detailed description of the companies' general activities, and information on the people involved in the interviews is presented in the following. A summary of the companies' branch of activity is presented in Table 8.

Table 8. Companies audited in Finland – branch of activity.

Case number	**Company's branch of activity**
Case VII	Manufacturing of industrial textiles
Case VIII	Manufacturing of heavy moving machinery
Case IX	Cleaning and repairing of industrial textiles

THE COMPANY IN CASE VII

The company in Case VII manufactured special textiles for industry. The company had about 1200 employees, half of which worked in the studied factory. The company had implemented two years ago a quality system based on the ISO 9001 quality standard. The factory had operated for ten years in the current premises. The production was running in three shifts.

The company had a part-time safety manager, who also was in charge of the production planning activities of the company. He had worked as a safety manager for three years. In addition to the safety manager, the company's safety representative participated in the interview.

The number of occupational accidents had decreased from 65 per one million work hours to 30 during the past three years. In 1993 the total number of lost workdays was 344. Of these, 152 days were due to an accident while commuting between home and the workplace.

THE COMPANY IN CASE VIII

The company in Case VIII manufactured heavy moving machinery. This factory employed about 800 people, 500 of which worked in the production plant. The company had two years earlier implemented a quality management system based on the ISO 9001 standard. The company's part-time safety director, the employees' safety representative, and one of the supervisors participated in the interview.

THE COMPANY IN CASE IX

In Case IX, the company's main activities included renting, cleaning and repairing of plastic textiles used in industry. The company had 28 employees, excluding the administrative personnel which consisted of the factory manager, a supervisor, and a secretary. The company was established in 1956, and it was recently incorporated into a large multinational company. The company's headquarters is located in another city. The company had a part-time safety manager in the plant, and he was also the person who participated in the interview.

6.3.2 Description of the companies' safety activities

A summary of the assessments in Cases VII-IX is presented in this section. The summary is categorized according to the activity areas of the D&S method.

ORGANIZATION AND ADMINISTRATION

The companies in Cases VII and IX had no written safety policy. However, in both of these companies, it was stated that there is a general understanding of the safety responsibilities and accountability. Furthermore, in Case VII the safety supervisor considered the company's quality system to also cover the health and safety issues, and a separate safety program was not necessary. In Case VIII, the company had incorporated the safety policy into the company's quality management system. In this company, most of the safety responsibilities were also defined in the quality system. The company's safety director pointed out that nowadays some of the company's customers also require a documented safety management system.

In Case VII, it was stated that the top management's commitment to health and safety is not visible, and that only few safety related objectives or activities are defined by the management. In Case VIII, the company's management had implemented a "continuous improvement" program which included, among others, health and safety issues. The safety manager in Case IX stated that the management's involvement with health and safety issues was not very visible. However, it was said that accident statistics were reviewed by the management. The situation was partly due to the company's organizational changes which meant that most of the management was now located in Helsinki.

Written safety instructions to hazardous tasks were available in Cases VII and VIII. In Case VII, the company's quality system also included the rules for preparing and updating the work instructions. In Case VIII, the instructions were available in the workplace, and they were updated regularly. Furthermore, it was stated that the supervisors ensure that the instructions are obeyed. The company in Case IX had not prepared any written work instructions for hazardous tasks. However, according to the company's safety manager, the employees' work experience was sufficient to guarantee an adequate level of safety.

In all cases, the company's occupational health service personnel carried out pre-employment health surveys. Also, regular follow-up surveys were done in order to see whether the employees' health status was changed. In Case IX, it was mentioned that especially the physical qualities of the new candidates are checked, since the work includes some physically demanding tasks.

The companies in Cases VII and VIII had prepared an emergency and disaster control plan. These plans included the definition of the personnel's responsibilities in emergency situations. In Case VII, emergency situations were trained together with the city fire department. The company in Case IX had no plans for emergency situations. According to the company's safety manager, these plans were not needed since the risk was estimated to be very low.

In Case VII, no written plant safety rules were available. However, when necessary, the safe work practices were reviewed together with the work instructor. In Case VIII, the safety rules were included in the material used for the training of new employees. These materials were also updated on a regular basis. The company in Case IX had no written safety rules, but according to the safety manager, the employees' work experience and training was sufficient to guarantee safe working. Furthermore, most of the machines included user instructions from which the employees could also find the safety precautions.

The company's safety activities were not systematically measured in Case VII. However, the company's health service personnel provided the safety manager and line managers occasional feedback on the health status of the employees. In Case VIII, the company's safety organization arranged a quarterly safety review together with the departmental managers. In Case IX, the effectiveness of the safety system was mainly evaluated by the local safety manager. This was seen as a sufficient arrangement because of the small size of the plant.

In Case VII, line management and the supervisors were to a great extent responsible for carrying out the safety activities. Besides this, the company's safety manager and the safety representative were quite active. The company in Case VIII had a well-performing safety committee which also prepared an action plan for itself each year. The company in Case IX arranged four safety committee meetings per year. According to the safety manager, the committee was seen as something that exists only because of the legal requirement. Safety issues were mostly discussed directly between the employer and the safety manager.

The companies in Cases VII and VIII had a health service center of their own. Besides nursing and carrying out health surveys, their personnel participated in the safety walk-throughs together with the safety organization. The company in Case VII had a trained first-aid squad which was within reach in 3-4 minutes, 24 hours a day. In Case IX, the health services were realized through a private medical center located near the company. This center was actively following employees' health status, and the medical doctor visited the company regularly. Because the work included some physically heavy work tasks, special attention had been paid to employees' neck and shoulder area problems.

INDUSTRIAL HAZARD CONTROL

The housekeeping and storage of materials was at an acceptable level in all companies. In Case VII, the employees were encouraged to maintain good order by housekeeping programs. In Case VIII, the persons interviewed stated that housekeeping is under special supervision. However, it was known that, for example, the air-hoses on the walking surfaces were an accident risk. Employees were encouraged to keep the working areas clean. Walking areas were marked, and no material was allowed to be stored in these areas. Also, storage areas were clearly marked on the production plant. In Case IX, the control of hazards had improved after the current supervisor came on duty. The new supervisor required, for example, that good order should be maintained at all times. The walk-through around the site confirmed this situation.

The machine guards were adequate, and their condition was frequently monitored in Case VII. Furthermore, the emergency-stop systems were installed, and light-curtain systems were used in hazardous areas when necessary. In Case VIII, the company's safety representative wished he could participate more often in the selection of new machines and equipment. However, company's machinery, including the flexible manufacturing system, seemed to be properly guarded. The safety manager stated, in Case IX, that the company's machines have adequate safeguarding and they do not require any additional safety equipment.

General safety of the work environment was good in all the companies. In Case VIII, attention was paid to health and safety in the workplace design. This was realized, e.g. by isolating the welding places from the other production areas. The safety manager in Case IX stated that the manual handling of materials was the most hazardous task. Inside the factory, the material was mainly transported using heavy, manually pushed carts. New handles were recently designed for these carts in order to avoid bruises to hands.

The maintenance procedures were documented in the company's quality management system in Case VII. The company's safety manager also stated that new machines and equipment were thoroughly tested before taking into use. In Case VIII, a preventive maintenance program was established for special equipment like the lifting device. The safety manager in Case IX stated that the maintenance program is adequate considering that the machinery is quite uncomplicated and safe to use.

The company in Case VII had no heavy manual material handling tasks. Also, some equipment were developed for helping material handling. One hazard was caused by the heavy reels moved by a crane, and sometimes transported above working areas. In Case VIII, all objects weighing more than 10 kilograms were handled using a lifting device. According to the safety manager in Case IX, the greatest health hazard originated from the manual handling of textiles. Each piece of textile weighed 30-60 kilograms, and they were handled by two workers together. Especially drying and repairing of the textiles required frequent manual lifting. In order to decrease the load, some new work methods had been applied, and new models of dryers had been tested.

The employees were provided with adequate personal protective equipment in all companies. In Case VII, the supervisors followed the use of the equipment. The company in Case VIII organized an on-site safety equipment exhibition for the personnel each year. In Case IX, the company provided the safety glasses, ear plugs, gloves, and protective work clothing. Furthermore, safety shoes were available at a reduced price.

FIRE CONTROL AND INDUSTRIAL HYGIENE

Chemical hazards were in good or excellent control in the companies. In Case VII, the MSDSs were located at company's library, and at the central chemical storage. However, they were not available at the workplaces, and employees were not trained in using them. In Case VIII, handling of chemicals was properly organized, and employees knew how to use them. New chemicals were not taken into use before the MSDSs were available. In Case IX, chemicals were used only in the cleaning of the textiles. The properties of these detergents were well-known by the workers.

In Cases VII and VIII, the persons interviewed stated that the storage of flammable materials had been done according to the fire authorities' regulations, and that only a few days stock of these materials was stored to the workplace. In Case IX, other fire-hazardous materials, aside from the small amounts of detergents, were not used. The storage of these materials was properly organized.

Ventilation was quite well arranged in all companies. In Case VII, however, some improvements were still possible in the dye-works department. The ventilation equipment systems were recently reconstructed, but the employees where still not quite satisfied with the system. The quality of air was measured when the employees or the supervisor found it necessary. Constant health control was provided for the employees who worked in the dye-works department. The company in Case VIII had several welding workplaces where local ventilation was not possible to arrange. In these tasks, personal respirators were used. In Case IX, minor hydrochloric acid releases occurred when the textiles were repaired. For collecting the acid, a vacuum system had been installed, and the operation of the system had recently been tested by an independent test laboratory.

According to the persons interviewed in Cases VII and VIII, the skin-irritating chemicals were under control, and employees had an opportunity to check the properties of the chemicals from the MSDSs. In Case IX, the detergents used for cleaning the textiles were, to some extent, skin-irritating. However, special gloves were available for employees handling these materials. Occupational health service personnel also instructed employees in the use of irritating and other harmful chemicals.

In Case VII, special training was arranged for those employees who carried out fire hazardous tasks. These tasks had been identified together with the local fire authority. Smoke detectors and sprinklers were assembled at the production plant. Some of the employees had received emergency and first-aid training. In Case VIII, the company had a fire department which consisted of ten firemen and three fire-engines. The insurance company had classified the level of fire safety as good. In Case IX, the minimum fire control requirements were met. However, during the visit to the plant, some violations against the fire safety rules were detected. Also, the fire-fighting equipment were not adequately sign-posted. The company's fire guarding was taken care of by a contractor who visited the site regularly 24 hours a day.

SUPERVISORY PARTICIPATION, MOTIVATION, AND TRAINING

Supervisor safety training was organized in several ways in the companies. In Case VII, the company had not provided systematic safety training for the supervisors. However, those supervisors responsible for asbestos works and fire hazardous tasks had received special safety training. In Case VIII, all supervisors had received safety training, and additional training was available for special problems. Furthermore, a record was kept of each supervisor's training history. In Case IX, there was only one supervisor in the company, and he had received only occasional safety training.

The company in Case VII had an instructor for the training of new employees. The training was, however, only verbal. In Case VIII, new employees were usually trained by a senior worker. The training was mostly verbal, but written documents, for example the MSDSs, were used in the training when necessary. In Case IX, the company had assigned one of the employees as a work instructor. Together with the supervisor, this instructor guided the new employee to proper work methods.

Some job hazard analyses had been done in Case VII. In the most mechanized production department, a systematic analysis had been carried out. In Case VIII, a hazard analysis had been done for the flexible manufacturing system, and especially for the robots. In Case IX, the safety of the punch presses and some of the handtools had been checked.

Training for some specialized operations was given in all the companies. In Case VII, many of the production machines required special operator training. Besides this, training was given for truck-driving and some other hazardous tasks. In Case VIII, the persons interviewed claimed that necessary training was given for all work tasks, and hazards were included in the training scheme. Guidance for correct manual lifting techniques was given in Case IX.

Internal self-inspections covered the electrical equipment, the earth gas systems, and the lifting device in Case VII. Checklists were the main tool used during the inspections. Otherwise, internal inspections were not seen to be necessary, and no written instructions were available for this activity. In Case VII, the *continuous improvement* scheme was seen as the way to identify potential hazards. The company in Case IX claimed that the safety personnel were able to identify potential hazards during their everyday work. Thus, there was no need for special safety analyses.

In Cases VII and IX, the main means for promoting safety was the posters and other safety material posted on wall-boards. However, the large production area in Case VII caused some problems in presenting the material to everyone. The company in Case VIII had an internal semi-weekly newsletter which also handled safety issues. Besides this, the wall-boards were actively used for presenting safety related information.

Safety communication between the supervisor and the employees was claimed to be good or excellent in all cases. In Case VII, it was stated that the communication varied but there were no problems with the safety contact between the supervisors and the employees. In Case VIII, employees discussed safety matters mainly with the safety representative. However, when the supervisor was giving work instructions to the employees, safety issues were also discussed. In Case IX, safety matters were discussed mainly while instructing the worker into the new tasks.

ACCIDENT INVESTIGATION, STATISTICS, AND REPORTING

In Case VII, the major accidents were investigated, while minor accidents and accidents which had occurred on the way to or from the workplace were usually not investigated. However, all accidents related to electricity were investigated. The supervisor investigated the accidents together with the injured employee. Accidents were discussed in the safety committee, and in some cases the committee organized a more thorough investigation. The line management did not follow the accident reports systematically, but they reviewed the current situation once or twice a year. In Case VIII, all incidences which had required some medical treatment were classified as occupational accidents. All these accidents were investigated, and the accident reports were delivered to the safety manager. The current accident investigation form was considered to be poor. It was presumed, however, that the recently changed new insurance company would also provide better investigation forms. In Case IX, accidents were investigated only to the degree that was required by the insurance company for receiving the compensation. The investigation form was filled out by the company's secretary.

In Case VII, the safety manager followed the accident statistics and trends. However, he pointed out that there was not enough time for reviewing the reports thoroughly enough. The safety manager also presented the statistics to the top management. However, the accident data was only occasionally utilized when improvements were planned. As a result of this, safety resources were sometimes used for ineffective and useless activities. In Case VIII, the statistics were posted for the personnel on the bulletin boards. In addition, the statistics were discussed in the safety committee and in the departmental meetings. In Case IX, experiences on the accidents were used for improving safety, and the work environment in general.

In Case VII, it was stated that information on near-accidents seldom reaches the supervisors. Thus, these incidents were not investigated either. In Case VIII, some of the near-accidents were investigated, although not systematically. In Case IX, it was stated that minor accidents and near-misses are not investigated.

6.3.3 Results of the Case studies VII–IX

The companies obtained the highest ratings for the activity areas: *Industrial hazards control*, and *Fire control and industrial hygiene*. In the other activity areas, the ratings were somewhat lower, and also the variation between the companies was greater (Table 9).

Table 9. Author's ratings of each activity area in Cases VII-IX. The maximum score is 20 for each activity area. A maximum total score is 100.

Activity area	Case VII	Case VIII	Case IX
Organization and administration	10.6	19.0	10.2
Industrial hazard control	19.2	20.0	16.4
Fire control and industrial hygiene	17.4	19.0	16.4
Supervisory participation, motivation and training	12.0	16.6	9.2
Accident investigation, statistics and reporting	14.0	15.6	9.6
Total score	**73.2**	**90.2**	**61.8**

The companies in Cases VII and IX had no written safety policy. However, in Case VII, the company had adopted a quality management system based on the ISO 9001 standard, and the company's safety manager claimed that the quality system also covered the health and safety issues. In Case VIII, the safety policy was included in the quality management system documentation. In Finland, at the time of the study, the management was not obliged by law to prepare a health and safety policy or program.

As far as it was possible to verify, the companies had fulfilled all the legal requirements, including the establishment of a safety organization, and preparation of the necessary documentation. All companies had appointed a safety manager, a safety representative, and a safety committee. Also, all the companies had provided the employees with the occupational health services. Two years before the study, the law on emergency and disaster control plans was passed in Finland. The two large-scale companies had prepared this plan.

Industrial hazard control, as well as fire control and industrial hygiene standards were at a high level in all companies. The level was somewhat higher in Case VIII than in the other two companies. To what extent the company's safety policy or the quality management system had improved these activities, was not possible to clarify.

The supervisors' safety training is often problematic in small companies. This was noticed also in this study. The company in Case IX had only one supervisor, and he had not received any particular safety training. On the other hand, the large-scale company in Case VIII had provided the supervisors several safety courses. Furthermore, this study strengthened the presumption that a small company can easily lack some safety knowledge.

All the companies investigated some of the lost time accidents. In Case IX, it was stated that the investigations are done mainly because the insurance company requires a description of the event. In the two bigger companies, the investigation procedures were somewhat more advanced. However, the weak point in all the companies was that the accident data and accident statistics were not systematically reviewed by the line management or the top management, and that no action plans to avoid similar accidents were prepared.

The total scores obtained by the author in Cases VII-IX were between 61.8 and 90.2. This shows there were clear differences between the companies. The small company (Case IX) received the lowest rating while the large metal company (Case VIII) received the best rating. However, the ratings were, according to the author's prior experience, within normal variation among Finnish companies.

6.4 Applicability of the D&S method

This section discusses the usability of the D&S method as a tool for safety auditing. The reliability of D&S based on the Case studies I-VI is presented and discussed is Section 6.4.1. The reliability based on Case studies VII-IX is presented in Section 6.4.2. Finally, conclusion on the general applicability of the D&S method is discussed in Section 6.4.3.

6.4.1 Reliability – based on Case studies I–VI

THE SCORES GIVEN BY THE AUTHOR AND THE COMPANY'S EVALUATORS

The scores obtained by the author and the company's evaluator in each case study are presented in Table 10. From this table has been derived Table 11 which shows in how many cases the author's assessment and the company's assessment were identical, or in how many cases the deviation was one level, two levels or three levels.

There were major differences between the author's and the company's assessment in Case IV and in Case VI. The company in Case IV was a large manufacturing plant with almost 3000 employees. One reason for the differences can be that three hours was too short a time for an external auditor to get a thorough view of the company's safety activities. Furthermore, the author had a chance to see only some of the company's production areas during the visit on-site, and the image received by the author could have remained narrow also for that reason.

In Case VI, there were also remarkable differences between the author's and the company's results. There can be several reasons for the differences. One of the reasons could be the fact that the person who completed the internal audit had only six months experience in his work as a safety director. Unfortunately, no possibilities existed to subsequently clear up the reasons for the differences.

Also the company in Case V is worth studying in more detail. In this company, the person interviewed was a very experienced safety expert. During her time as a personnel manager and the person responsible for the safety program, the accident rate had decreased dramatically. This development was probably the reason why in her assessment all the activities were considered to be in excellent level. The author also found that most activities were well organized and implemented, but some improvements seemed to be still possible.

Table 10. The author's and the company personnel's scores in Cases I-VI. (A = Author's assessment, C = Company's assessment).

Activity	**Case I**		**Case II**		**Case III**		**Case IV**		**Case V**		**Case VI**	
	A	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**	**A**	**C**
A1. Statement of policy	4	3	4	4	3	2	4	4	4	4	4	1
A2. Management involvement	3	3	3	3	4	3	4	4	4	4	3	2
A3. Instructions to hazardous tasks	4	2	3	2	4	2	4	3	4	4	2	1
A4. Workplace design	3	3	3	2	3	3	2	3	4	4	2	2
A5. Emergency control plans	4	3	4	4	2	3	4	2	4	4	4	1
A6. Plant safety rules	1	3	3	3	2	3	4	4	4	4	4	1
A7. Measurement of activities	3	3	4	4	3	3	4	1	3	4	2	1
A8. Safety organization	4	3	4	4	4	3	4	4	4	4	3	1
A9. Health care	3	4	3	3	3	2	3	3	3	4	3	1
B1. Housekeeping	4	4	3	4	4	4	3	2	4	4	4	1
B2. Machine guarding	4	3	4	4	4	4	4	3	4	4	4	1
B3. General safety	3	3	4	4	4	4	4	4	3	4	4	2
B4. Maintenance of equipment, etc.	4	3	3	4	4	3	4	3	4	4	4	2
B5. Material handling	4	4	4	2	4	3	2	3	4	4	3	1
B6. Personal protective equipment	4	3	4	3	4	3	4	4	4	4	4	1
C1. Chemical hazard control	3	3	4	4	4	4	4	4	4	4	4	1
C2. Storage of flammable materials	3	4	3	2	4	4	4	4	3	4	4	1
C3. Ventilation – dust control	2	4	4	2	4	3	4	4	4	4	4	2
C4. Skin contamination control	4	4	4	3	4	3	4	3	4	4	4	2
C5. Fire control measures	4	4	4	2	3	2	4	4	4	4	4	1
D1. Line supervisor safety training	2	2	3	4	2	2	4	2	4	4	1	2
D2. Training of new employees	2	3	2	3	3	3	4	3	3	4	3	3
D3. Job hazard analysis	4	3	3	4	2	2	4	3	4	4	4	3
D4. Training for special operations	3	2	3	3	2	3	4	3	4	4	4	2
D5. Internal self-inspections	4	3	4	3	3	3	4	2	4	4	4	2
D6. Safety promotion and publicity	3	3	4	3	2	2	4	2	4	4	4	2
D7. Safety communication	3	3	3	2	2	2	2	2	4	4	3	1
E1. Accident investigation	4	2	4	4	4	4	4	4	4	4	4	2
E2. Accident analysis & statistics	3	3	4	4	3	3	4	4	3	4	4	2
E3. Near-accident investigation	2	1	3	4	4	3	3	1	4	4	2	3

Table 11. The degree of agreement between the author and the company's evaluator in Cases I-VI. The table shows in how many cases the deviation was 0, 1, 2 or 3 levels.

Activity	**Deviation**			
	0	**1**	**2**	**3**
A1. Statement of policy	3	2	0	1
A2. Management involvement	4	1	1	0
A3. Instructions to hazardous tasks	1	3	2	0
A4. Workplace design	4	2	0	0
A5. Emergency control plans	2	2	1	1
A6. Plant safety rules	3	1	1	1
A7. Measurement of activities	3	2	0	1
A8. Safety organization	3	2	1	0
A9. Health care	2	3	1	0
B1. Housekeeping	2	3	0	1
B2. Machine guarding	3	2	0	1
B3. General safety	4	1	1	0
B4. Maintenance of equipment	1	4	1	0
B5. Material handling	2	2	2	0
B6. Personal protective equipment	2	3	0	1
C1. Chemical hazard control	5	0	0	1
C2. Storage of flammable materials	2	3	0	1
C3. Ventilation – dust control	1	2	3	0
C4. Skin contamination control	2	3	1	0
C5. Fire control measures	3	1	1	1
D1. Line supervisor safety training	3	2	1	0
D2. Training of new employees	2	4	0	0
D3. Job hazard analysis	2	4	0	0
D4. Training for special operations	2	3	1	0
D5. Internal self-inspections	2	2	2	0
D6. Safety promotion and publicity	3	1	2	0
D7. Safety communication	4	1	1	0
E1. Accident investigation	4	0	2	0
E2. Accident analysis & statistics	4	1	1	0
E3. Near-accident investigation	1	4	1	0

THE ACTIVITIES OF THE D&S METHOD HAVING THE MOST AMBIGUOUS CRITERIA

In the following, those activities of the D&S method are discussed where the deviation between the author's and the company's assessment was more than one level in the rating scale. Also, possible causes for the differences are proposed when possible. The results from Case VI, where the differences in the interpretation of the criteria were largest, are not included in the presentation.

Organization and administration

The determination whether the safety instructions to hazardous tasks (A3) were adequate was difficult to do in Case III. The bias may have been due to the difficulty of determining for which hazardous tasks safety instructions should have been made. In Case IV, the contents of the emergency and disaster control plans (A5) was interpreted differently by the author and the company's evaluator. For this activity, the company's assessment was more strict than the author's assessment. The company in Case IV was a large one with almost 3000 employees. Thus, the bias in this case may be due to the fact that the company's evaluator knew the potential disaster sources better than the author, and had concluded that the activity was not adequately put into practice. Also, the criteria for the plant safety rules (A6) seemed to be inaccurate (Case I). Finally, the criteria for the measurement of the safety activities (A7) were somewhat imprecisely defined. This can be seen especially in Case IV where the author's rating was a "4" (excellent) and the company's assessment was a "1" (poor).

Industrial hazard control

The results show that industrial hazard control was at a high level in all participating companies. Both the author, and the companies' evaluators obtained high scores. It can also be argued that the results were so uniform because the criteria were so loose. For instance, the requirements for maintenance procedures, material handling, and the use of personal protective equipment are nowadays easily met. The only major bias was detected in Case II in the analysis of material handling procedures (B5), where the author's rating was a "4" and the company's rating was a "2".

Fire control and industrial hygiene

Ventilation as well as fire control measures (C3) seemed to be inaccurately defined in the D&S method (Case II). The author estimated that the quality of ventilation met all requirements while the company's evaluator would have improved the exposure measurement, equipment selection, and maintenance procedures. The company's evaluator would also have liked to improve fire control measures. However, in this explicit case, the author estimated that fire control was at an adequate level considering the nature of the production which had practically no fire hazards. In Case I, the author found the air quality to be fair because of the oil fumes, while the company's evaluators did not consider the fumes a problem.

Supervisory participation, motivation and training

In this activity area, the criteria seemed to be well defined since no major differences were found between the author's assessments and the companies' assessments. There was some bias only in Case IV where the company's evaluator found that the internal self-inspections (D5) should have been done more thoroughly than at present. Again, the disagreement probably occurred because of the large size of the plant where the author could not get an adequate image of the situation.

Accident investigation, statistics and analysis

A major difference occurred in the interpretation of near-accident investigation in Case IV. According to the company's evaluator, near-accidents were not investigated. By contrast, the author had come to the conclusion that near-accidents were investigated according to the company's written instructions. An explanation can be that the instructions were prepared but near-incidences were, despite the instructions, not investigated. In this activity area, the criteria for the two other activities seemed to be well formulated since no major deviations occurred.

THE INTER-OBSERVER RELIABILITY

The strength of the overall agreement between the author and each of the company's evaluators was also analyzed statistically. The computation was done using the formula for weighted kappa (κ_W) (see Section 5.3). The values of κ_W as well as the strength of agreement associated to each value are presented in Table 12.

The relative strength of agreement between the author and the companies' evaluators was from "poor" to "moderate" when the assumptions of Landis & Koch (1977) are used (see Section 5.3). Thus, it seems that at least some of the criteria of the D&S method are indeterminate. Standards or other references do not include any limit values for the inter-observer reliability in auditing. However, the author sees that in this case, the degree of reliability achieved can not be considered to be sufficient.

Table 12. The relative strength of overall agreement between the author and the companies' evaluators in Cases I-VI.

Case	**Value of κ_w**	**Strength of agreement**
Case I	0.205	Fair
Case II	0.161	Slight
Case III	0.465	Moderate
Case IV	0.210	Fair
Case V	0.000	Slight
Case VI	–0.027	Poor

6.4.2 Reliability – based on Case studies VII–IX

The scores obtained by the author and the students in Case studies VII-IX are presented in Table 13 - Table 15. In each table, also the mean of the scores, as well as the standard deviation of the students' results are shown. In the last row of each table, the strength of the overall agreement between the author and each of the students is calculated. The agreement was studied using the formula of weighted kappa (κ_w), and the strength of agreement was evaluated using the definitions of Landis & Koch (1977) (cf. Section 5.3).

The relative strength of agreement between the author and the students was from "fair" (κ_w = 0.355) to "almost perfect" (κ_w = 0.832). If the author's assessment is considered to be the "correct" one, then it seems that most of the students could reliably assess the health and safety activities of the companies.

The strength of agreement between the author and the students was also higher than between the author and the companies' evaluators in Cases I-VI. There can be several explanations to this. In Finland, the students based their ratings on exactly the same information that was available for the author. Also, the cultural background of the author and the students was the same. The only difference was the longer experience that the author had in assessing corporate safety management systems. Finally, the standard deviations among the students show that the D&S method has several activities for which the criteria are very well defined.

Table 13. The scores obtained by the author and the students in Case *VII. (A = author's scores, S1 - S6 = student's scores, Mean = arithmetic mean of the students' scores, SD = standard deviation of the students' scores,* κ_W *= strength of agreement between the author and the student*).

Activity	**A**	**S1**	**S2**	**S2**	**S4**	**S5**	**S6**	**Mean**	**SD**
A1	2	2	2	2	2	2	2	2.00	0.00
A2	1	1	1	1	1	1	1	1.00	0.00
A3	4	4	3	3	4	4	3	3.50	0.50
A4	4	4	4	3	4	4	3	3.67	0.47
A5	4	3	3	3	4	3	3	3.17	0.37
A6	1	1	1	1	1	1	1	1.00	0.00
A7	2	1	2	2	2	2	2	1.83	0.37
A8	3	2	3	2	3	3	3	2.67	0.47
A9	4	3	4	3	3	3	3	3.17	0.37
B1	4	2	3	4	3	4	3	3.17	0.69
B2	4	2	3	3	3	3	3	2.83	0.37
B3	3	3	3	3	4	3	3	3.17	0.37
B4	4	3	4	2	4	3	3	3.17	0.68
B5	4	3	3	3	4	4	3	3.33	0.47
B6	4	4	4	3	4	4	3	3.67	0.47
C1	3	4	3	2	2	3	3	2.83	0.69
C2	4	3	3	3	3	3	3	3.00	0.00
C3	3	2	2	2	2	3	2	2.17	0.37
C4	4	3	4	2	4	4	4	3.50	0.76
C5	3	2	3	4	3	3	3	3.00	0.58
D1	2	2	2	1	1	2	2	1.67	0.47
D2	3	4	4	4	4	4	4	4.00	0.00
D3	2	1	2	2	2	2	1	1.67	0.47
D4	4	3	3	2	3	3	2	2.67	0.47
D5	2	2	2	2	2	2	2	2.00	0.00
D6	2	2	2	1	2	2	2	1.83	0.37
D7	4	2	3	3	3	3	3	2.83	0.37
E1	3	2	3	2	3	3	2	2.50	0.50
E2	3	3	3	3	4	3	4	3.33	0.47
E3	2	1	1	1	2	1	2	1.33	0.47
κ_W		0.577	0.796	0.534	0.795	0.832	0.627		

Table 14. The scores obtained by the author and the students, as well as the statistical computations in Case VIII.

Activity	**A**	**S1**	**S2**	**S3**	**S4**	**S5**	**S6**	**S7**	**Mean**	**SD**
A1	4	4	3	4	3	4	3	4	3.57	0.49
A2	4	4	4	3	3	4	3	4	3.57	0.49
A3	4	4	4	3	3	4	4	4	3.71	0.45
A4	4	4	4	4	4	4	4	4	4.00	0.00
A5	4	3	3	3	3	3	3	3	3.00	0.00
A6	4	4	4	4	4	4	4	4	4.00	0.00
A7	3	3	3	4	3	4	3	3	3.29	0.45
A8	4	4	4	4	3	4	3	3	3.57	0.49
A9	3	3	4	3	3	4	3	3	3.29	0.45
B1	4	3	4	3	3	4	4	3	3.43	0.49
B2	4	4	4	4	4	4	4	4	4.00	0.00
B3	4	4	4	4	3	4	4	4	3.86	0.35
B4	4	4	4	4	4	4	4	4	4.00	0.00
B5	4	4	4	4	4	4	4	4	4.00	0.00
B6	4	4	4	4	3	4	4	4	3.86	0.35
C1	4	4	4	4	4	4	4	4	4.00	0.00
C2	3	4	3	4	2	3	2	2	2.86	0.83
C3	4	3	3	3	3	4	4	4	3.43	0.49
C4	4	4	4	4	4	4	4	3	3.86	0.35
C5	4	4	4	4	4	4	4	4	4.00	0.00
D1	4	4	4	4	4	4	4	3	3.86	0.35
D2	3	3	3	4	3	3	3	4	3.29	0.45
D3	2	4	2	3	2	2	2	2	2.43	0.75
D4	4	3	4	4	3	3	3	3	3.29	0.45
D5	3	4	3	3	3	3	4	4	3.43	0.49
D6	4	4	4	4	4	4	4	3	3.86	0.35
D7	3	3	3	3	3	3	4	3	3.14	0.35
E1	3	2	3	2	2	3	4	2	2.57	0.73
E2	4	3	3	2	3	2	4	4	3.00	0.76
E3	2	3	2	2	2	2	3	2	2.29	0.45
κ_W		0.356	0.780	0.440	0.558	0.673	0.555	0.604		

Table 15. The scores obtained by the author and the students, as well as the statistical computations in Case IX.

Activity	A	S1	S2	S3	S4	S5	S6	Mean	SD
A1	2	1	2	2	2	2	2	1.83	0.37
A2	2	2	2	2	2	2	2	2.00	0.00
A3	3	2	2	2	2	2	2	2.00	0.00
A4	4	3	3	2	3	4	4	3.17	0.69
A5	1	1	1	1	1	1	1	1.00	0.00
A6	3	2	2	1	2	2	3	2.00	0.58
A7	3	2	2	2	3	3	3	2.50	0.50
A8	3	2	2	2	2	2	2	2.00	0.00
A9	4	3	4	3	3	3	3	3.17	0.37
B1	4	3	2	3	4	4	4	3.33	0.75
B2	3	2	2	3	3	2	3	2.50	0.50
B3	3	3	2	3	3	3	3	2.83	0.37
B4	4	3	3	3	3	3	3	3.00	0.00
B5	1	2	2	1	1	2	1	1.50	0.50
B6	4	2	2	2	2	2	2	2.00	0.00
C1	4	3	4	2	4	4	4	3.50	0.76
C2	4	3	1	2	3	4	4	2.83	1.07
C3	3	4	4	4	4	4	4	4.00	0.00
C4	4	3	3	3	3	4	4	3.33	0.47
C5	2	3	2	2	2	2	1	2.00	0.58
D1	2	2	2	1	2	2	2	1.83	0.37
D2	2	4	3	2	2	2	2	2.50	0.76
D3	2	2	1	1	2	2	2	1.67	0.47
D4	3	2	2	1	1	2	2	1.67	0.47
D5	2	2	1	2	2	2	2	1.83	0.37
D6	2	2	2	2	2	2	2	2.00	0.00
D7	3	2	2	2	3	2	2	2.17	0.37
E1	2	2	2	2	3	2	2	2.17	0.37
E2	3	2	2	1	3	3	3	2.33	0.75
E3	2	2	2	1	2	2	2	1.83	0.37
κ_W		0.405	0.375	0.355	0.622	0.711	0.771		

6.4.3 Conclusions on the applicability of the D&S method

When the audit results of the author and the company evaluators are compared with each other, several differences can be found. In general, the company evaluators were more strict in their interpretation of the criteria than the author. One reason for this could be that the author had more experience in the use of the method than the company personnel, and the author adjusted the rating scale according to the type and size of the plant. Another reason for the differences can be the fact that the author was not completely familiar with the legal and other requirements that the companies must fulfill. The safety and health legislation in the USA is slightly different from that in Europe and in Finland.

The strength of agreement between the author and the companies' observers was generally at a lower level than the strength of agreement between the author and the students. The explanations to this can be the different professional and cultural background of the observers, and the way the audit data was collected. In this study, the author and the company observers had different cultural background, and also the professional background was unequal. Compared to the students, the author had the same cultural background, and the professional background was not very different. The author and the students had exactly the same data for the judgment. The company personnel, on the other hand, had a long experience of their own safety activities, and they were also probably very capable of identifying the deficiencies in their safety activities.

It can be summarized, that the D&S method seems to give low inter-observer reliability when the observers have different professional or cultural background, and high reliability when the background is equal. Besides this, the auditor's knowledge on the local health and safety legislation seems to influence the results. Thus, the study shows that in the use of D&S method, the audit results are greatly dependent on the quality of the auditor. Another finding of the study is that the available data has influence on the audit results. Reliability improves when the auditor has enough time for the on-site activities, i.e. interviews and document reviews. The reliability of D&S can be considered sufficient when attention is paid to these circumstances.

Some of the criteria of the D&S method are somewhat loose regarding today's requirements. For example, the requirements for the control of industrial hazards, fire hazards, and industrial hygiene should be more tight than they are at present in the D&S. The D&S method also puts relatively lot of weight to industrial hazard control. On the other hand, very little attention is paid to mental stress due to complex work situations or the use of information systems. These stress factors were, naturally, of less importance when the method was first developed. Also adjustment of the weights should be considered among these activities.

The policy, organization and administration has relatively little weight in the method. Modern audit methods seem to put more emphasis on these elements (cf. Table 5 in Section 4.5.6). On the other hand, the D&S method includes several elements for the motivation, leadership and training activities. These are seen as very important still today. Finally, the pro-active measurement methods should have more weight. The current D&S method sees that only accidents are safety outcomes that should be statistically analyzed.

The D&S method has many weaknesses, but when they are realized the method is applicable in many ways. Firstly, it is suitable for carrying out an initial health and safety status review (cf. Section 3.4). Based on such a review, a company can establish or revise its safety policy. In small and medium-sized industrial companies, the D&S method alone can be a sufficiently thorough audit method. For a large company, the D&S method alone is often too general. By dividing the company to smaller units, e.g. to departments, the D&S method might be an effective tool for a local safety assessment.

The case studies showed that the D&S method can be used both in Finland and in the USA. The method does not include such elements which would be irrelevant or otherwise unusable in either of the two countries. In fact, the Finnish companies and safety authorities are currently emphasizing many such activities that are seen important in the D&S method. These activities include the development of a safety policy, management involvement, emergency control plans, management safety training, internal self-inspections, safety communication, and near-accident investigation. The modifications that were made to the original D&S method updated the method’s contents and criteria, and thus probably also improved the method’s usability.

The D&S is clearly an industrial audit method. Thus, many of the method's criteria can be irrelevant when used in other branches. Also, in very small companies some of the requirements may be negligible. For example, a small company seldom needs a safety committee or other special safety organization. This means that the criteria of the D&S must be reconsidered in these cases.

6.5 Comparison of the audit results: USA and Finland

6.5.1 The ratings

The differences in safety performance between the companies in the USA and Finland are illustrated in Figure 8. With one exception, the scores for organization and administration were at a somewhat lower level in the Finnish companies. Industrial hazard control as well as fire control and industrial hygiene were at a high level in all companies. The observed variation was greatest in supervisory participation, motivation and training activities, where the highest and lowest ratings were found in companies from the USA. The score for this area was over 15 in only one of the Finnish companies. Accident investigation, statistics and analysis procedures were clearly at a higher level in the companies audited in the USA.

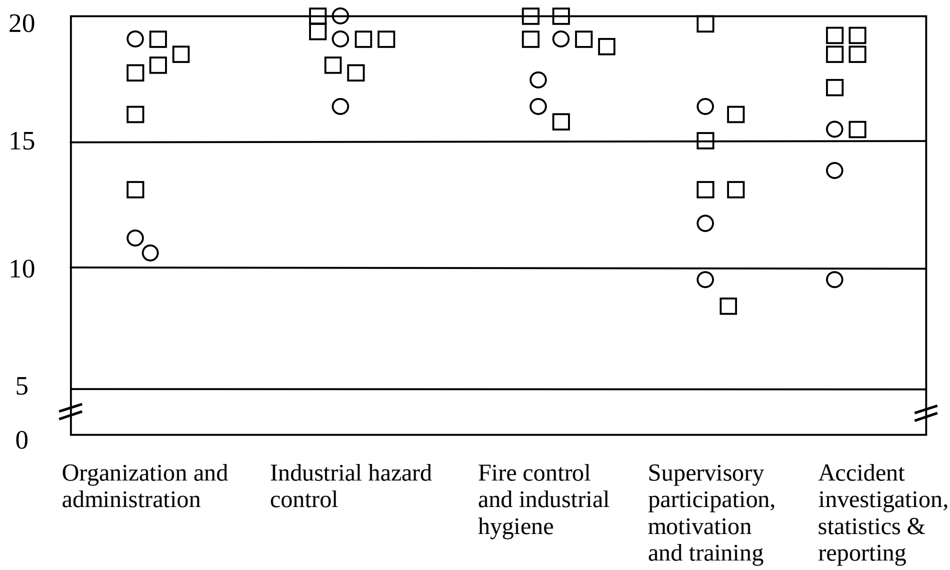

Figure 8. The author's ratings in nine companies using the D&S audit method. Cases marked with a square are from the USA, and the cases marked with a circle are from Finland. The maximum score for each activity area is 20.

The differences between the Finnish and the US companies were also evaluated statistically. The two-sided p-value was computed from the individual scores for each activity area as well as for the whole assessment (Table 16). The differences in safety performance were statistically significant in activity area E: *Accident investigation, statistics and analysis.*

Table 16. Differences in safety performance between the companies in the USA and in Finland. The p-values were calculated using Mann-Whitney's U-test.

Activity area	**Two-sided p-value**
A. Organization and administration	0.405
B. Industrial hazard control	1.000
C. Fire control and industrial hygiene	0.310
D. Supervisory participation, motivation and training	0.381
E. Accident investigation, statistics and analysis	0.048
The overall assessment	**0.214**

6.5.2 Discussion on the differences

All the companies in the USA had a written safety policy, while only one of the Finnish companies had it. The Finnish company which had defined the policy, had included it into the company's quality management system.

An explanation of this difference could be that at the time of the study, the concept of safety management was not widely known among Finnish companies. Many companies defined their first strategic and operational policies when their started to develop an ISO 9000 based quality management system in late 1980s. Defining a safety policy has usually been a continuation of this activity. Similarly, the environmental policy was defined in many companies in mid 1990s, as a result of the implementation of the ISO 14001 based environmental management system. In the USA, safety management has a longer history as a standard procedure among industrial companies (cf. Sections 3.1 and 4.1). Thus, it has also been a common procedure to establish a safety policy to define the basic goals of safety management.

Direct management involvement in health and safety activities was at a higher level among the companies in the USA. There can be several cultural and historical reasons for this. The safety consciousness of the employees can explain part of this phenomenon. For example, Schonberger (1982) and Wobbe (1990) have claimed that shop-floor workers in the USA are less trained and less adaptable than those in Europe or in Japan. If this is the situation, the employees are probably also less conscious of the risks at work. This leads to a situation where the supervisor must take more responsibility for the workers' safety. In an audit, this can be interpreted as high management involvement.

The safety organization's structure can explain to some extent the poor management involvement among the Finnish companies. By law, the Finnish companies must establish a multi-level formal safety organization (cf. Section 3.5). In this situation, there is a danger that the accountability of the management and expertise of the safety organization get mixed. This can lead to that management gradually assigns some of its legal duties to the safety organization, and simultaneously the management's direct involvement decreases.

There were also some differences in the way how occupational health services were arranged. In Finland, the employer in obliged to organize health services for all employees. These services include, by law, visits to the workplaces in order to find possible health hazards, and relationships between the occupational diseases and the working conditions. In the USA, the health service personnel does not normally participate in safety walk-throughs or other workplace surveys. Common to both countries is that the OHS personnel carries out pre-employment health surveys, and regular check-ups throughout the employment.

The control of visible hazards was at a high level in both countries. This indicates that there should be no major differences in the quality of the physical work environment. This assumption is supported by the fact that the Incidence Rates are very close to each other in Finland and in the USA (cf. Section 1.1).

The greatest dispersion occurred in the supervisory participation, motivation and training activities. A major difference occurred in the safety promotion activities. The companies in the USA had adopted several safety incentives, like safety contests and safety rewards. In Finland, special programs for motivating personnel to safe work practices are not commonly used. It can also be argued that in Finnish workplaces safety is more a value itself, and it does not need to be promoted using incentives. This statement was, however, not possible to verify in this study.

One of the companies in the USA also put a lot of emphasis on off-the-job safety. This company mailed some of the safety related material to the employees' homes, and had also included the employee's family in the health insurance scheme. The idea of taking care of the employer's off-the-job safety is not exceptional or new among the companies in the USA. This can be seen, for example, from the originally American ISRS safety audit method which includes one element for this activity (cf. Table 4 in Section 4.5). In Finland, companies' health and safety programs only seldom cover any off-the-job activities. There are, however, some large-scale companies which have sickness funds for their personnel, and these funds also cover the costs of off-the-job accidents and illnesses.

Accident and near-miss investigation, statistics and analysis procedures were predominantly better arranged in the USA than in Finland. In the USA, the

OSHA regulations for record keeping are very strict which means that the employer must record all lost workday accidents (Accident facts 1997). In Finland, employer must report the lost workday accidents to the insurance company when claiming the compensation. The main difference between the two countries was in the way how statistics are analyzed, and used in the determination of new safety goals. In this activity, the companies in the USA were better. Another difference was in the analysis of near-accidents which was at lower level in the Finnish companies.

There can be several reasons for the different practices in accident and near-miss analysis. One reason can be that Finnish companies do not have such a strong “learning from accidents” culture. Another reason can be due to the different insurance systems. In the USA, insurance premiums are strongly connected to the company’s accident rate, while in Finland this connection is not so clear.

Based on the results, it is not possible to say that safety management in general would be better arranged in either of the two countries. This is due to several reasons. The small number of companies involved in the case studies is one thing that restricts the generalization of the results. Another factor is that the selected companies do not necessarily represent the average standard in industry. It can be assumed that in both countries, the case study companies were above the average national level in their safety activities.

Despite the limitations, it is possible to draw some conclusions. The individual safety activities examined in the study showed that in some areas, there are clearly national differences in the ways of doing safety work. How significantly these different practices affect health and safety outcomes is difficult to determine based on these studies. The accident statistics show that industrial enterprises in the USA have a somewhat lower accident rates than similar companies in Finland. Whether this is a result of more thorough accident investigation and analysis practices, more effective safety promotion and training, different leadership style, or just a different way of compiling national accident statistics, is not clear. More thorough comparative studies should be done before any reliable conclusion can be made.

7. Development of the MISHA method

7.1 Introduction

The review on current safety audit methods (cf. Section 4.5), as well as the Case studies I-IX revealed that there is still room for improvements in the current audit methods. At least three things seem to need special attention: 1) the audit method should cover all the key functions of safety management, 2) the method should support high reliability of the audit results, and 3) the time and personnel resources needed in the use of the method should be reasonable. The first requirement is obvious if we are considering *management safety audit* types of methods which were described in Section 4.3. The second requirement arises from the fact that the results are not valid if the audit tool does not promote high intra-observer and inter-observer reliability. The third point is that the effort used for the audit process should be in proportion to the expected benefits.

For an organization, it is essential that the safety audit clearly identifies the activities that require improvements. When an audit concentrates on the key activities of safety management, it can be considered that all activities are equally important. This leads to a model where the relative importance of all activities is the same, and the use of weights is not necessary. According to Cooper (1998), establishing the weighting factors for each of the various elements of an audit tool can be a painstaking and time-consuming work. Furthermore, he states that a simple “yes”, “no”, “don’t know” format will suffice in most instances. This keeps the method simple, but it allows the calculation of a score by adding up the number of “yes”, “no”, and “don’t know” responses.

The above described findings were the basis for the development of a new health and safety audit method called the MISHA (Method for Industrial Safety and Health Activity Assessment). The objective was to develop a comprehensive health and safety audit method which would have high reliability when used by trained auditors either from inside or outside the company. The contents of the MISHA method is not designed to be permanent. The activities to be assessed can be changed or modified on demand.

The development of MISHA was carried out in two phases. The first version was developed using an expert group which had previous experience in safety audit methods. At this stage, also comments and criticism was received from several other experts and colleagues of the author. The first version was then tested in one company. The results of this test indicated that the method requires further development. The second, modified version was then tested in another company. Testing of the MISHA method is described in Chapter 8.

7.2 Structure of the MISHA method

The MISHA method is primarily designed to be used in middle and large-size industrial companies. The most appropriate industrial sectors are manufacturing and process industry. In a large organization having several independent processes or locations, it is advisable that a separate audit is carried out in each area. The area should be determined in the preparation stage by the auditor or the audit team together with the company's management.

The audit process should have a leader who can be either from inside or outside the organization. The internal auditor can be, for example, the company's quality manager, safety manager, administrative manager, or a person in charge of the maintenance activities. The auditor should have prior experience in health and safety activities. In addition, the auditor should carefully examine the MISHA audit method before the on-site activities. Other practices that should be followed with the MISHA method, are those presented in Section 4.4.

The MISHA method has a multi-level structure (Figure 9). The four main activity areas (A-D) are analogous with the key functions of safety management as described by Booth & Lee (1995) (cf. Section 3.3). These four main areas are divided into sub-areas (A1, A2 ..., B1, B2 ..., etc.). The sub-areas include then the individual activities to be assessed.

A. Organization and administration	B. Training and motivation	C. Work environment	D. Follow-up
A1 Safety policy A2 Safety activities in practice A3 Personnel management	B1 Safety training of the personnel B2 Work instructions B3 Incentives to safe work practices B4 Communication	C1 Physical work environment C2 Psychological work environment C3 Analysis of the work environment	D1 Occupational illnesses D2 Occupational accidents D3 Occupational diseases D4 Work ability of the personnel D5 Social work environment

Figure 9. The activity areas of the first version of the MISHA method.

Each individual activity includes: 1) the activity to be assessed, 2) the related issues to be considered in the assessment, and 3) the scoring system. An example of the structure is presented in Figure 10.

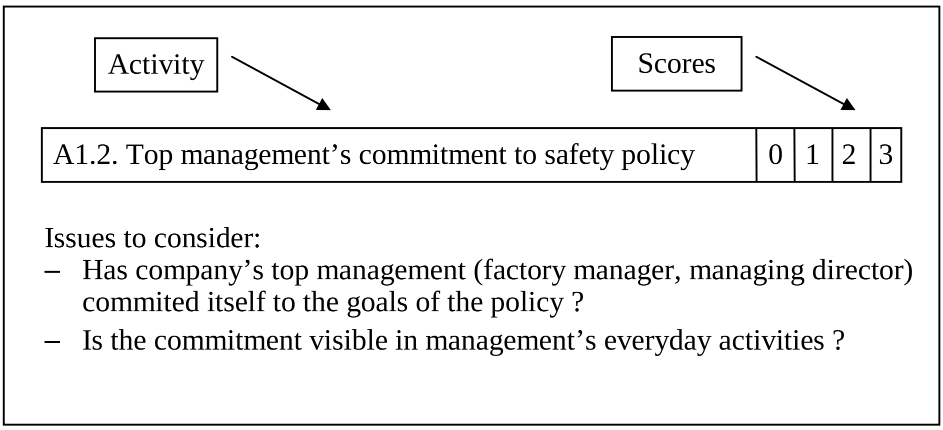

Figure 10. Example of an individual activity assessed in the MISHA method.

7.3 The scoring system

Audit conclusions should guide the company to improve those activities which need actions most urgently or which are currently at the lowest level. In the MISHA method, this was arranged by giving each activity a score which describes how well the activity meets the predetermined requirements. The scoring system is uniform, although not totally identical, with the one used in the Malcolm Baldrige Quality Award (cf. Malcolm ... 1994). The requirements and the corresponding scores are presented in Table 17.

Table 17. The requirements and the corresponding scores in MISHA.

Requirements	**Score**
All issues to be considered are put into effect without weaknesses or deficiencies. A strong improvement process is in use.	3 points
Improvement process is put into practice. Activity standards and rules are obeyed. There are no notable deficiencies in activities.	2 points
Activity is at minimum level. Rules and the modes of action are determined and notified. In some areas activities are only problem-solving in nature. However, activities are mainly sensible and applicable.	1 point
Activity is not at acceptable level. Rules and modes of actions are determined only verbally. No visible activities can be seen, or activities are only problem-solving in nature.	0 points

The safety activity rating can be calculated from the given scores. The rating can be computed either to a single activity area or to the entire assessment. As an example, the rating for activity area (A) is calculated as follows:

$$\textit{Activity rating (A)} = \frac{\textit{Sum of scores for activity area (A)}}{\textit{Maximum available scores for activity area (A)}} \; x\, 100\,\% \qquad (3)$$

The total activity rating is calculated as follows:

$$\textit{Activity rating (tot)} = \frac{\textit{Scores (A) + Scores (B) + Scores (C) + Scores (D)}}{\textit{Sum of maximum available scores for activity areas (A-D)}} \; x\, 100\,\% \qquad (4)$$

8. Testing of the MISHA method

8.1 Case study X

DESCRIPTION OF THE COMPANY

The company manufactures metal products from sheet metal plates. It employs 900 persons, 450 of which work in the manufacturing plant. The manufacturing is divided into four departments. For the audit, a department which had 130 employees was selected. Typical work tasks in this department included sheet metal cutting and forming, assembly work, and electrical installation works. The company had a certified quality management system based on ISO 9001 standard.

The organization had a company manager, and a local manager at each manufacturing department. The safety personnel consisted of a safety director, a part-time safety manager, and two part-time employees' safety representatives. Besides these, the company had a person responsible for the environmental safety activities. The company had its own health service center with a physician, two nurses, and a secretary.

PREPARATION OF THE AUDIT

The first phase of the audit (preparation), was carried out by a group which consisted of the company's safety director, safety manager, quality manager, and the author. In this phase, the scope of the audit was defined, and the personnel to be involved was determined. Also, it was decided that the company's safety manager would be responsible for arranging the meetings with the participating persons. He also should be present in all occasions during the audit process. However, the author would conduct all the phases of the audit process.

During the first phase, it was also determined how the second phase (on-site activity) would be realized. It was decided that the personnel would be interviewed in three stages. First, there would be a meeting with the management and the safety personnel. Second, the health service personnel would be interviewed. Finally, some of the employees and one of the supervisors would be interviewed. The health and safety related documents would be reviewed during the visits on-site.

The total time that was used for interviewing the management was about 5 hours. The interview with the health service personnel took about 2 hours, and the discussions with the employees and the supervisor lasted about 1,5 hours.

DESCRIPTION OF THE SAFETY ACTIVITIES

Organization and administration

The company had a short written safety policy where the main safety principles were presented. The policy was not signed by anyone, but it was approved by the top management. It was posted on company's wall-boards, and it had been published in the company's internal bulletin. The policy was delivered to the safety authorities and the customers, and on request also to the sub-contractors.

A more detailed safety brochure had been made for the company's quality training material. The brochure put a lot of emphasis on the safety committee's and the safety representative's role, but it did not clearly show the management's role and responsibilities. Thus, the brochure indicated that most of the safety activities are carried out by the formal safety organization. According to the brochure, the safety manager's main role was to organize the safety activities within the company.

The safety policy had been prepared by the line management in cooperation with the top management. The process of including the health and safety policy and the related documents into the company's quality system was under discussion.

The top management and the line management were aware of the personnel's health status and safety in a general level. Employees' main health hazards were realized and the work environment's major accident risks had been identified. The supervisors had recently attended a two days health and safety course where topics like the supervisor's safety responsibilities, and hazard identification methods had been discussed.

The company's safety committee included nine members, and one of them was from the occupational health services. The role of the committee was not very clear, and it was claimed that the committee seldom discusses any major topics. The top management was well-informed about the committee's work, and it provided external experts to committee's disposal when necessary.

The safety manager had been in his post for one year. According to him, there was sometimes too little time to carry out all safety duties. The employees' safety representative was able to use four days a week for safety activities. Although he had attended several safety courses, also outside the company, he felt that some further training would be beneficial.

Occupational health services were provided for the whole personnel. The company's health service center prepared for every two-year period a plan where its main activities were determined. These activities included health hazard surveys on the plant, guidance of employees on health issues, health monitoring of employees, health promotion programs, plans for monitoring the disabled employees, first-aid training plans, and nursing.

Procedures for the selection and placement of personnel were well-defined. Whether the employees' current placement is optimal, was considered twice a year. The personnel resources were planned for three years ahead. The employee selection and placement was done by two persons from the line management. The professional skills, education and previous work experience determined whether a new candidate was employed or not.

The new supervisors and line managers were selected from within the company. Their leadership abilities were occasionally tested before the placement. It was pointed out that a manager should be able to motivate employees, for example, to safe work practices rather than to be very authoritarian.

Job rotation was used on the shop-floor level, and this practice made it possible for the employees to learn new work tasks. The company also supported workers who were willing to learn new skills. One method to increase work satisfaction was the annually paid 15 % productivity bonus.

According to the safety manager, new tools and equipment are always available when they improve safety. The need for new hand tools was normally considered in the maintenance department.

Training and motivation

All employees had received some training for the quality system. In the production plant, the training of employees to new skills was a continuous process. According to the management, the persons in the safety organization had received thorough training, but the line management's safety training was inadequate. The management also claimed that training to work is given to all those employees who begin with a new work. A sufficient number of people had received first-aid training.

The supervisors arranged the training in practice. They went through the general work agreements with the new employee, showed the workplace, and introduced the tasks briefly. A senior worker's responsibility was to give the detailed training to the new employee. In some cases, also the manufacturer of a new production system or machinery trained the users inside or outside the company. The company had prepared a short written safety brochure to be used during the training. During the past few years, the number of employees had not increased, and the turnover had been minimal. For this reason, also the training needs had been small.

There was no record of those persons who had been trained for special operations like truck driving or welding. However, every worker doing a fire hazardous job, had to attend a special course. There also used to be internal courses for truck driving, but these courses had not been arranged for many years. The company's aim was to have multi-skilled workers, and truck driving was something that all employees were supposed to learn.

Written work instructions were available for the hazardous or otherwise critical tasks. These instructions were also required by the company's quality management system. The employees had not participated into the preparation of the instructions. According to the employees, some of the instructions were not useful, and they were made only for the quality system itself. The work instructions were updated regularly, and the updating process was described in the quality management system.

The identified health and safety hazards were discussed mainly between employees and the supervisors. However, some of the employees felt that there was not enough daily communication between the supervisors and employees.

Employees' suggestions for improving health and safety or other conditions at workplace were collected and handled by a special committee. The written suggestions were to be forwarded directly to the committee's secretary, since there were no collection boxes in the plant. This system was initiated six months prior to the audit. None of the employees interviewed was aware of the new system and the committee. The committee's task was to review the suggestions on a monthly basis, and to reward good ones.

The company had an internal bulletin which was published monthly or bi-monthly. Wall-boards and monthly departmental meetings were the other means of regular communication. Supervisors, as well as some of the employees and their representatives attended these meetings.

An employee who finds a potential hazard on the plant, usually informs the supervisor about it. In case the supervisor does not take the necessary actions on the matter, the employee usually discussed the problem with the safety representative.

A housekeeping program was accomplished four years earlier, and since that no safety campaigns had been carried out. The health service center had arranged several courses on first-aid and health promotion on an annual basis.

The company's information center ordered health and safety related material on a regular basis. Besides this, the health and safety personnel ordered a lot of material directly from equipment manufacturers, and safety research institutes.

Work environment

There was a common understanding that it is primarily every supervisor's duty to arrange hazard identification activities at work. Besides this, the occupational health service personnel checked the potentially hazardous workplaces once a year. This was done in order to find to what extent workers are exposed to health hazards, and whether workers need additional health surveys for this reason.

A project group was established every time a major production re-design or layout modification project was started. The OHS personnel was also willing to participate to the work of these groups. However, this was not the normal procedure, since the OHS was seldom informed about these projects.

The control of chemical hazards was at high level. The supervisor or a senior worker guided and instructed new employees for the handling of chemicals. In the pre-employment medical examinations, there was an attempt to find those persons with a potential to allergy. In case an allergy occurred, the employee's placement was reconsidered. Most of the chemicals were selected by the company's paint storage-keeper. According to the supervisor, the MSDSs were available and updated frequently. However, there seemed to be a need for a centralized system for the maintaining and updating of the company's MSDSs.

Muscular work load was not a major problem in the company. Many of the manual sheet metal handling, forming and cutting tasks had been removed by automation. However, some heavy lifting tasks including unsatisfactory postures were found. Recently, one of the employees had been given a lighter work for this reason. The company's health service personnel evaluated working postures and musculoskeletal loads when visiting the production plant.

Noise was in control, and no major problems had occurred. During the past year, the noise levels had been measured in all production areas. The average noise level in the studied department was between 70-80 dB(A). According to the workers interviewed, the main source of disturbing noise were the employees' radios.

The adequacy of the illumination had recently been measured. During this check, the maintenance personnel had changed 3500 lamps in the factory. The temperature was well-controlled in the manufacturing area. However, some local temperature variations occurred, and in summer the temperature was sometimes too high. Air-conditioning was installed only into the office premises.

A lot of effort was used for ensuring the safety of machines and equipment. A special project group was responsible for ensuring the health and safety in an assembly project. In practice, this was done by discussing safety issues with the users, and people from the safety organization. Also, the expertise of Safety Inspectorate was frequently used during major mechanical installation projects.

During the past year, 57 accidents occurred at the workplace, and 15 accidents on the way to work or from the work. These figures include also the management and the administrative personnel of the company. Accident prevention efforts were put to on-the-job hazards. It was claimed that slipping accidents and traffic accidents that were typical outside the plant, were difficult to reduce.

The company's maintenance department seemed to work effectively. For example, the key machines and equipment were defined in the quality system, and they were in a preventive maintenance scheme. Cleaning and housekeeping was done both by the company's own personnel and by a cleaning service firm.

The control of major hazards was ensured by appropriate planning and analyses. Hazard analyses were conducted for the most hazardous tasks. However, in the interview it was not possible to clarify the typical major hazards. Exits were well-marked in all parts of the production plant.

Mental factors were not systematically taken into account in the workplace and work process design. According to the company's management, "common sense" was the main method for taking mental stress into account in the company's operations. The personnel manager claimed that the majority of employees could do more demanding tasks than they do now. Also, most of the workers were willing to take more responsibility on their work than they do now.

According to the employees, it is important that the responsibilities are clearly defined. They found that some of the work instructions are too complex and unclear, causing confusion and stress. Other mental stress factors that employees had experienced were the general haste, as well as some monotonous tasks, for example in the painting section. According to the company's health service personnel, most of the problems with mental stress come up in the health surveys, and during the OHS safety reviews on the plant.

Company's safety organization together with the health service personnel reviewed the plant safety visually on an annual basis. Besides the annual reviews, the company's health service personnel visited those workplaces where health problems had occurred. These reviews were carried out as walk-throughs which included interviewing of the personnel. The results of the observations were reported to the safety personnel and to the department's supervisors and line management. In addition, the safety committee sometimes reviewed the reports. Once a year, the physician reported personally the company's top management upon the personnel's health status. Furthermore, the company's personnel manager followed closely the work ability and health status of the personnel.

The safety personnel consisted of a safety manager and two safety representatives. The safety manager had been appointed by the top manager of the plant. One of the representatives had been elected by the production workers, and the other one by the administrative staff.

Follow-up

In the past year, the working time lost due to occupational accidents and illnesses was about 4 % of the total work time. This is less than the average figure in Finnish industry (5.3 % in 1994) (Työaikakatsaus 1995). According to the personnel manager, reduction of the lost days would require that the reasons for the absenteeism have been identified. Currently, effort was put for improving manual material handling, since half of the lost days were related to musculoskeletal disorders.

The statistics on occupational and other illnesses were kept by the company's occupational health service personnel, and a summary of the statistics was done every six months. The absenteeism statistics were kept by the department of personnel management. On request, the supervisor could have the statistics concerning his department.

The Cases Incidence Rate (CIR) was 47 cases per one million work hours. This number is low compared to the average of 86 cases in the Finnish metal manufacturing industry in the year 1994 (Työtapaturma- ja ammattitautitilasto 1995). The statistics were done once a month, and the results were sent to the factory manager. In the beginning of the year, the top management set for the first time a goal for decreasing the number of accidents. Occupational illnesses were very rare, only 1-3 cases annually. Most of these cases were hearing impairments. These cases are included in the accidents statistics. A computerized system was in use for keeping up the accident records.

The accidents were usually investigated by the safety manager together with the safety representative. In addition, a supervisor and a person from the maintenance department sometimes participated in the investigation. The supervisor and the injured person together filled in the accident report for the insurance company. The personnel manager reviewed all reported incidences from the investigation reports. However, no systematic procedure was in use for utilizing the accident investigation data in accident prevention.

The employees' work ability was followed systematically by the company's health service personnel. OHS personnel used the Occupational Stress Questionnaire (OSQ) on a regular basis for measuring the mental well-being of the personnel. The OHS personnel also pointed out that they would be willing to participate more actively into the selection and placement of the new staff. The OHS also mentioned that all supervisors are not able to evaluate employees' physical and mental work abilities.

When an employee's placement had to be reconsidered for health reasons, the situation was discussed together with the supervisor, the physician, and the employee.

The employees relied on the health service personnel's expertise. In many cases, the employees discussed their health problems and work ability directly with the company's OHS personnel, and not with the supervisor. It was said that this practice has sometimes caused information loss between the employee and the supervisor.

The quality of social climate, and the personal relationships were surveyed every five years by an external consulting company. The results of this survey were reported properly, but handled inside the company somewhat ineffectively. For example, the company's own health service personnel had only received the report on this survey, but was not able to communicate or cooperate with the consulting company. Sometimes suggestions to measure the social climate had been discussed in the meetings arranged between the local labor union and the employer.

8.2 Results of the case study X

THE RATINGS

In addition to the author, four members of the company's personnel made their own independent assessment using the MISHA method. The results of the assessments are presented in Appendix C. The ratings obtained by each of the evaluators are presented in Table 18.

Table 18. The activity ratings obtained by the evaluators in Case X.

Activity area	**Evaluator**					
	AU	PM	SD	SR	SM	$\bar{x}$
A. Organization and administration	61	61	61	46	72	**60.3**
B. Training and motivation	51	56	62	49	73	**58.2**
C. Work environment	54	60	60	56	75	**61.3**
D. Follow-up	50	57	20	57	70	**50.7**
Total activity rating	**55**	**59**	**55**	**51**	**73**	**58.6**

AU = author
PM = company's personnel manager
SD = company's safety director
SR = employees' safety representative
SM = company's safety manager
$\bar{x}$ = arithmetic mean

The company's safety manager was most satisfied with the current state of safety activities. He did not find serious deficiencies in any activity area. On the other hand, the safety representative found that there were a considerable number of activities that could be done better. According to him, especially the functioning of the safety organization as well as the training and motivation activities were ineffective. According to the author's prior experience, safety manager's and the safety representative's assessments are seldom uniform. This is probably because the safety manager feels the responsibility of the activities, and is more willing to see that everything is orderly managed. On the other hand, the safety representative who has less formal power, is often more critical.

The author received very similar ratings with the personnel manager and the safety director. A major difference occurred only in the follow-up procedures where the safety director found these activities to be at low level. The reason for this deviation was, however, not possible to clarify.

The author was most critical compared to the others when assessing the quality of the work environment. This can be due to the phenomena that people are often blind to their everyday work environment, and do not see the possible hazards as clearly as an external observer.

RELIABILITY

The strength of the overall agreement between the author and the other evaluators is presented in Table 19. The weighted Kappa coefficient of agreement was used in the calculations. The strength of agreement is based on the definitions of Landis & Koch (1977) (cf. Section 5.3).

Table 19. The overall agreement between the author and the company's evaluators in Case X.

Author by	**Value of weighted Kappa (κ_W)**	**Strength of agreement**
company's personnel manager	0.08	Slight
company's safety director	0.35	Fair
employees' safety representative	0.06	Slight
company's safety manager	0.36	Fair

The reliability computations show that the agreement between the author and the other persons was not very good. Although the ratings of the author were very uniform with those of the personnel manager and the safety director, the inter-observer reliability remained only slight or poor. Thus, by looking only at the ratings it was possible to come to the conclusion that the results are very uniform, while there were in fact several different viewpoints among the auditors.

The author's assessment was closest to the results of the company's safety manager. This is a somewhat unexpected result, since the ratings between the author and the safety manager were not very close to each other. On the other hand, it seems that the author and the safety director identified the same hazards, but the author was more strict in the assessment.

VALIDITY

No validity studies were carried out for the reasons presented in Section 5.3. However, validity was considered by collecting the accident data from the company. This data was then categorized to accident types. After that, the correlation between the audit findings and the accident types was considered. The company's accident statistics were collected from the past 29 months.

The accident data was categorized according to the employee's activity when the accident occurred, or the surrounding conditions at the time of the event (Table 20). This was the most convenient way for the categorization from the available data. Only accidents that led to an injury to a person are included. First-aid accidents with no lost-days are also included. The accidents that took place while commuting between home and the workplace are excluded.

Table 20. Accident types in Case X, (n = number of accidents, f = frequency).

Accident type	**n**	**f (%)**
Slip of a handtool	34	22
Falling or collapsing object	23	15
Pinching of hand or fingers, caused by a machine	22	14
Flying object or liquid to eye	19	12
Acute low back injury due to lifting	16	10
Slippery walkway outdoors in factory area	11	7
Overexertion injury (excluding back)	6	4
Slippery or uneven walkway inside factory area	6	4
Hitting foot to an object	5	3
Others	15	9
Total	**157**	**100**

In order to receive more accident data, all the production departments of the plant where included. The use of this larger data probably does not cause bias, since the department that was audited was strongly under the influence of the total company management system. For example, the company manager, the personnel manager, the safety director, the employees' safety representative, and the safety manager were responsible for the whole plant.

The most typical injuries were minor cuts to hands. These were caused by hand tools or the machinery. Moving objects or irritating liquids were the other primary causes for accidents. Physical work load caused only 14 % of the accidents, but resulted 50 % of the lost days.

The correlation between the accident types and the audit results is not very clear. The auditors found most easily the problems related to the implementation of the safety activities, e.g. safety training, management's safety feedback, campaigns, and follow-up. There was a common understanding among the auditors that the tools and machinery are adequately safe. It can be summarized that more emphasis should be put to safety training, improvement of safety knowledge among the management, motivation to safe work practices by increased management feedback, safety campaigns, and better follow-up of the safety results.

8.3 Case study XI

FURTHER DEVELOPMENT OF THE MISHA METHOD

The first testing of the MISHA method revealed that very high reliability cannot be achieved on the use of the method. Also, it was found that the on-site audit process was quite time-consuming. This was partly due to the fact that some activities over-lapped each other. As a result, it was seen necessary to develop a second version of the MISHA method.

In the new version, the basic structure of the method was left unchanged. Some of the activity areas, and individual activities were grouped in a new way and/or linked together. The main changes were made to the "issues to consider" (cf. Figure 10 in Section 7.2). The aim of these changes was to make the scoring more accurate. The new framework of the method is presented in Figure 11. The overall method is presented in Appendix E. The scoring system remained the same as presented in Table 17 in Section 7.3.

A. Organization and administration	B. Participation, communication, and training	C. Work environment	D. Follow-up
A1 Safety policy A2 Safety activities in practice A3 Personnel management	B1 Participation B2 Communication B3 Safety training of the personnel	C1 Physical work environment C2 Psychological work environment C3 Analysis of the work environment	D1 Occupational accidents and illnesses D2 Work ability of the personnel D3 Social work environment

Figure 11. The activity areas of the second version of the MISHA method.

DESCRIPTION OF THE COMPANY

The company manufactured plastic products for consumers. It was established in 1950s and it employed 77 persons. The production operated 24 hours a day, and five days a week. The managing director was also one of the owners of the company. Typical work tasks included controlling of the machines, packing of the products, and transporting of the products to the storage. One employee could control simultaneously up to three machines. In total, 26 machines were operating in the plant. The company had no plans to adopt any type of a documented quality management system.

The company's safety organization comprised of the managing director who also acted as the safety manager of the company. In addition to this, the employees had elected a part-time safety representative. The company had a contract with a local private health service center.

PREPARATION OF THE AUDIT

The scope of the audit included the whole company. In this case, no exploratory visit was made prior to the interview on-site. Written material on the audit method, and description on the purpose of the audit was delivered to the managing director three weeks before the on-site process. The managing director informed the personnel about the audit beforehand, and distributed the material to the persons participating in the audit. In addition to the managing director, the maintenance chief, production manager, one of the production supervisors, and the employees' safety representative participated in the interview. The author conducted the audit process.

All the participating persons were interviewed during one session. This process took a total of four hours. Additional information was obtained during a walk-through on the plant after the interview. After the walk-through, one employee was interviewed. The nurse of the health service center was interviewed shortly two weeks after the visit on-site.

DESCRIPTION OF THE SAFETY ACTIVITIES

Organization and administration

The company had no written safety policy. Also, the safety responsibilities and safety related tasks were not documented. The company's safety principles and responsibilities were defined by the managing director, and they were communicated to the management and personnel orally.

Due to the small size of the company, the top management, the line management and the supervisors were able to follow the personnel's health and safety status quite closely. The company had established a safety committee with four members, but its meetings were irregular. The committee had no annual action plan to follow. The managing director pointed out that he can follow the health and safety activities and outcomes personally. He had not participated into any health and safety training. The employees' safety representative was quite active, and she claimed that she has the necessary time for her safety duties. However, she wished to receive more training in health and safety analysis. She had recently participated in a one week basic safety course.

The company had selected a new provider of the occupational health services some years earlier. The new OHS personnel seemed to work effectively, and they were also aware of the special problems of the plant. Health hazard surveys were conducted at the workplace once or twice a year. Pre-employment test were carried out for all new employees, and regular hearing test were done to the employees exposed to noise.

No planned resources were assigned for improving health and safety. The necessary resources were determined individually in each case. This system had worked well, and it was claimed that all the necessary safety investments have been made. Recently, a major effort was put on the safeguarding of the automated conveyer systems.

The average age of the employees was around 40 years. The volume of the production had been very stable for many years. Only a very few new persons had been employed during the past years. On an average, one or two employees were pensioned each year.

The selection and placement of employees was carried out by the line management and the supervisors. Only the persons in the key positions had been selected by the managing director. New supervisors were selected either from among the employees or from outside. New supervisor and line management positions had rarely been open during the past years.

Due to the small size of the plant, there were very few opportunities for career development. The wages were partly based on the collective agreements, and partly on individually paid production bonuses. The personnel working in the office, negotiated the salaries with the office manager.

Participation, communication and training

Communication between the supervisor and the employees worked well although it was claimed that supervisors do not give enough feedback on the quality of the work. Employees had very limited possibilities to participate in the design of their own work and workplace. No small-group activities had been implemented.

General communication was arranged mainly through wall-boards, and it was claimed to work well. Employees presented their suggestions for improvements directly to the supervisors – the box for suggestions had never been used. Campaigns for promoting health and safety had not been arranged for many years. According to the employees' safety representative, there was a need to inform personnel, for example, on protective work clothing.

The safety representative was the only person who had received external safety training. New employees were informed about health and safety issues during the initial training. No special work instructors were used – senior employees showed the work practices to newcomers. Written work instructions were available for the packing of products. Truck driving was considered a hazardous task, but no training or instructions were available for it. Some of the employees were specialized in driving a truck, but all workers were allowed to drive. Only specially trained persons were allowed to do maintenance work, and fire hazardous tasks.

Work environment

Health and safety was not systematically taken into account in the design of the physical work environment. The company had expertise in the field of ergonomics, since one of the line managers was a trained work analysis expert. However, this person had done these analyses only in his previous workplace.

The hazardous chemicals used in the plant consisted of some solvents and liquid fuels. The amount of these chemicals was very small, and they did not cause a major accident hazard. However, some problems associated to the chemicals occurred: the location of the MSDSs was not known by the persons interviewed, there was a shortage of some suitable personal protective equipment needed in the handling of solvents, and sometimes the gas bottles used in the trucks were stored on-site instead of a special storage place.

Manual lifting of the raw material and the finished products caused a considerable health hazard. The raw material was stored in 25 kg bags, and up to 400 bags were lifted by one person in a day. Besides this, in the storage of the finished products, units weighting up to 15 kg were lifted manually to the shelves.

The noise level was over 85 dB(A) in some areas of the plant. Personal hearing protectors were used irregularly, but the supervisors felt they cannot force the workers to use them. Suitable hearing protectors were, however, provided for all employees.

Illumination was not a major problem in the plant. However, there seemed to be a need to install some additional lightning fixtures to the workplaces where visual quality control was done. It was also mentioned that reflections from the computer monitor screens had been a problem in the office.

The season and the weather caused temperature variation inside the location. In a hot weather, the machinery produced heat that was not possible to transfer outside effectively enough.

The main primary cause for accidents was the inadequate housekeeping. The raw material was in the form of round (diameter about 4 mm) plastic grains which were often found on the floors. Also another housekeeping related problem was observed. The walking and working areas were often blocked by containers of raw material or by finished products and waste. The painted lines showing the truck-ways and the storage areas were mostly worn or totally missing.

There was no preventive maintenance program in use. However, it was claimed that the condition of the machinery is known by the maintenance personnel, and no unexpected damages have occurred.

Major accident hazards had lately been analyzed together with the insurance company. This analysis revealed that the production process does not include hazards that could lead to major damage to the environment or to the people inside or outside the plant. A fire fighting training had recently been organized for the employees.

Some tasks that could contribute to mental strain were found in the production plant. In one of the workplaces, the work task was almost entirely dependent on the speed of the production line. It was also mentioned that some work instructions were missing causing problems in doing the work. Furthermore, deficiencies in the design of noise reduction, and in the heating/cooling system could contribute to mental overload. On the other hand, employees could regulate the load to some extent by reducing the time spent in the unfavorable areas, and by using personal protectors. The plant supervisors as well as some of the office workers had claimed that the responsibilities should be defined better.

Workplace hazard surveys were done together with the safety authority when they visit the plant. These visits were done one or two times a year, and the surveys included a safety walk-through on the plant. The members of the safety committee participated into these walk-throughs.

Occupational health service was located outside the factory premises. Thus, they were not able to visit the plant very often. The OHS reported the management regularly the number of employees who had visited the OHS personnel. The OHS also made suggestions for a new placement when the employee's health status required that.

Follow-up

Statistics on occupational accidents and illnesses were kept by the OHS, the personnel management, and the insurance company. The safety authority reviewed these statistics during the visits to the factory.

Accidents were investigated by a group which consisted of the company's physician, the supervisor, and the maintenance chief. Serious accidents were investigated immediately. The unplanned absenteeism rate was followed up, and it was currently 2.1 % of the total work time.

Only in very few occasions, the work ability of an employee had decreased substantially. However, in the case that this would happen either the employee, the supervisor, or the physician would suggest a new placement for the person.

The workers preferred working hours were followed regularly. The working hours were a problem, e.g. for some of the older workers and for workers with children. Those who were willing to work only on the day shift, were placed on the packing department.

The quality of the social work environment had not been evaluated systematically. However, it was considered that the possible problems in the social climate usually turned up one or the other way, and actions were always taken to handle them.

8.4 Results of the case study XI

RATINGS

In addition to the author, four members of the company's personnel made their own independent assessment. The results of the assessments are presented in Appendix D. The ratings obtained by each of the evaluators are presented in Table 21.

Table 21. Activity ratings obtained by the evaluators in Case XI.

Activity area	**Evaluator**					
	AU	MD	MC	S	SR	$\bar{x}$
A. Organization and administration	36	30	39	29	28	**32.4**
B. Participation, communication, and motivation	33	39	58	30	12	**34.4**
C. Work environment	36	47	71	50	58	**52.4**
D. Follow-up	61	50	72	11	11	**41.0**
Total activity score	**38**	**39**	**55**	**33**	**31**	**39.2**

AU = author
MD = company's managing director
MC = company's maintenance chief
S = supervisor
SR = employees' safety representative
$\bar{x}$ = arithmetic mean

In this case, the ratings obtained were more dispersed than in Case X. The company's maintenance chief was clearly most satisfied with the current safety activities. However, since there was no safety policy prepared, also he obtained low rating for the organization and administration of the safety activities. Company's supervisor and the safety representative were somewhat more strict in their assessment than the author. The safety representative was most critical, as was the situation also in Case X. However, the safety representative found the work environment to be quite good. The author was most strict compared to the others when assessing the quality of the work environment.

RELIABILITY

The strength of the overall agreement between the author and the other evaluators is presented in Table 22. Weighted Kappa coefficient of agreement was used in the calculations. For the strength of agreement see Section 5.3.

Table 22. Overall agreement between the author and the company's evaluators in Case XI.

Author by	**Value of weighted Kappa (κ_w)**	**Strength of agreement**
company's managing director	0.58	Moderate
company's maintenance chief	0.50	Moderate
supervisor	0.41	Moderate
employees' safety representative	0.38	Fair

The strength of agreement between the author and the other evaluators was considerably better in this case than in Case X. This implies that the further development of the MISHA method led to increased reliability. In this case, the conformance was best between the author and the company's managing director. Since the managing director was in charge of the everyday management activities, it is probable that his result also reflects the real situation quite well.

VALIDITY

The method for the validity evaluation is here the same as in Case X. Accidents from the past 29 months were studied. The accident types, and their number and frequency are presented in Table 23.

Table 23. Accident types in Case XI, (n = number of accidents, f = frequency).

Accident type	**n**	**f (%)**
Slip of a handtool	4	26
Slippery or uneven walkway inside factory area	4	26
Overexertion injury (excluding back)	2	13
Falling or collapsing object	1	7
Pinching of hand or fingers, caused by a machine	1	7
Acute low back injury due to lifting	1	7
Slippery walkway outdoors in factory area	1	7
Falling down from an unstable platform	1	7
Total	**15**	**100**

Due to the small size of the company, also the number of accidents was small. However, it can be identified that the typical injuries were related to handtools, and the housekeeping of the plant. Besides this, manual material handling caused some problems, mainly overexertion of the back and muscular system. The lack of written safety rules, as well as inadequate supervision and daily safety communication can explain most of the housekeeping problems. The musculoskeletal overexertion can be due to the inadequate training for correct lifting techniques, or the lack of suitable lifting device. Interesting was that the author and the managing director found muscular work to be a problem while the others did not find any improvements necessary. This proves that an external auditor or a person not working in the area can identify some problems better than the persons staying most of the time in the area.

Hazard analyses or risk assessments were not carried out regularly in this company. However, three auditors did not find any problems with these activities. Only the author and the managing director identified this problem. Regular and systematic accident hazard assessments would probably have revealed that the housekeeping is at low level.

An interesting result was also the auditors' understanding of the follow-up procedures. The author, the managing director, and the maintenance chief found the follow-up procedures to be at acceptable level. The two other auditors found them to be at very low level. This shows that the auditor's see the acceptable level in different ways.

8.5 Summary

When the MISHA was designed, the aim was to create a comprehensive, reliable, and valid safety audit method. Whether the MISHA method can improve the reliability of auditing was tested in two companies. The first test indicated that the inter-observer reliability was not very good. Also, the test showed that some of the method's activities over-lap each other. Thus, the MISHA was modified and re-tested. In the second test, the agreement between the author and the company's evaluators was fair or moderate. This reliability level can be considered sufficient when we bear in mind that the company's evaluators were not trained for using the MISHA method.

The validity of the MISHA method was considered against the accident types and frequencies in the two companies. Some need for improvements can be found, also in the second version of MISHA. Firstly, the method should emphasize more the importance of risk assessments. Some auditors did not see the obvious weaknesses in the risk assessment activities in Case XI. In this case, these weaknesses clearly contributed to the poor housekeeping and slipping accidents. Secondly, the follow-up procedures is an activity that should be reconsidered in the MISHA method. It seems that the inexperienced auditors in Case XI did not have the knowledge on acceptable accident investigation and work ability assessment activities.

In Case XI, it was possible to see that the MISHA probably emphasizes too much the safety policy and safety documentation. In a small company, it is not always necessary to prepare and implement a separate safety policy. It might be enough if the company's management has defined a written safety program, and follows that it is effectively implemented. This kind of a program should cover, as a minimum, the definition of responsibilities, the risk assessment procedures, and the follow-up of safety results.

9. Discussion

9.1 Reliability of auditing and audit tools

Safety audit tools are somewhat different to those used in the auditing of quality management systems. Most of the current safety audit methods include a scoring system, and criteria for giving the scores. In traditional quality auditing, scores for evaluating the activities are usually not used. However, safety audit tools are closely related to Malcolm Baldrige type quality award systems which aim at showing how the situation has changed in the company since the previous audit. Baldrige Quality Award scores can be compared between companies, but this is not a common practice with current safety audit methods.

A safety audit process itself is very similar to that of a quality audit. Like with quality audits, special attention should be paid to the preparation of the audit, and to the selection of the auditor and the audit team. Also, the form of presenting the conclusions should be carefully planned. A well-prepared audit report is a good starting point for the design of an action plan.

Audit results should be consistent, meaning that there should be no bias between independent auditors' results. Good consistency means that the reliability of the auditor is high. In general, the use of a structured audit method gives high consistency. However, it must be remembered that reliability is also in connection with the validity of the method. Validity cannot be any higher than the reliability of a method. A structured safety audit method can be reliable, but the validity can be poor if the questions are wrong, that is, they do not assess safety management activities, but something else. On the other hand, an open method is usually less reliable, but an experienced auditor can probably obtain more valid results with it.

A safety audit tool may need modification when introduced in a country where the original method was not designed. Miss-matches can occur for example in the ways how safety activities are organized. In some countries, a company must assign some safety activities to a specific personnel or group. For example, safety managers, safety representatives, safety committees, and occupational health services can have specific duties.

The use of an international audit tools has also its benefits. These tools can emphasize such activities that are new and unknown in some countries. For example, in Finland off–the–job safety is a new concept for the majority of industrial companies. This element is included in the ISRS audit method.

In some cases an external evaluator can be more biased than the company's internal evaluator. For example, the company's own personnel are probably better aware of the safety activities in practice than an outside person. An external auditor's benefit is that he is not personally responsible for any safety activities in the organization. Furthermore, an external auditor has usually audited several different organizations, and has a large experience of good and poor safety management practices.

Nowadays, it is very common that quality auditors work in international certification companies. This practice is spreading also to safety auditing. A potential problem in this is that the auditor's knowledge on the national legislation and organizational practices is not sufficient. The auditor can, for example, evaluate the level of activities as poor although the activities are sufficiently organized in some other way.

Current safety audit tools try to improve at the same time both reliability and validity of the audit results. In methods like the D&S, ISRS, CHASE, and Safety MAP, the reliability has been increased by including some guidance for the assessment.

A method's validity seems to be more difficult to determine than reliability. The ISRS method, for example, has been validated by using accident data as reference. The various validity studies have, however, reached conflicting results. Thus, it can be argued that accident data alone is not a sufficient parameter for validity testing. A thorough validation probably requires the use of several parameters, like absenteeism rates, changes in the personnel's work ability, observation of the physical work-site, etc.

The case studies of this work showed that high reliability can be achieved on the use of the D&S method when the observers are familiar with the audit method, and the national legislation and culture. The reliability seems to decrease when the auditor is not familiar with the method (as the company evaluators in the

USA) or when the auditor is not familiar with the local conditions (as with the author's assessment in the USA).

The developed MISHA method was less structured than the D&S, but it included some guidance by defining the issues the auditor should consider in the assessment. This compromise resulted in a method which provides a lot of data, and at the same time leads to acceptable level of reliability.

9.2 National differences in safety activities

There are different national practices in how health and safety hazards are controlled in work organizations. At least three different strategies can be distinguished. These are summarized in the following. It must be remembered, however, that the description is generalizing the situation, and that there are surely many differences in national and local company level.

The *American model* emphasizes that ensuring health and safety is a responsibility of the management, from the top management level to the shop-floor supervisor level. Employee's role is not very active, and participation or teamwork are not commonly used. *In Europe*, companies rely on formal safety organizations at workplace, and often these are required by law. A typical organization includes besides the safety manager, a safety representative, a safety committee, and the health service personnel. Employees are more independent than in the USA, but teams are not widely used, and participation is often indirect through a representative. Finally, the *Japanese management philosophies* emphasize the employee's role in health and safety. Teamwork is seen as the key to effectively carry out improvements at work. Furthermore, Japanese see that individual's capabilities should be taken into account as much as possible, and that various methods to increase motivation should be in use.

The strength of the American practice is that the responsibilities and accountability are well-defined. The system is backed-up by the safety authorities (OSHA) through effective supervision and enforcement. The weakness of this practice is that employees' skills and capabilities are not used to full extent.

The European system has achieved several good results, for example relatively low accident rates. However, it seems that the lack of safety leadership has led to problems like low work motivation and work satisfaction. The results of this are seen, e.g. as mental problems and "burn-out". In Finland, for example, untimely retirements are very common, and mental disorders are the most common reason for the early retirement. Authority control is not as strict in Europe as in the USA, and the emphasis is in the safety programs and not so much in the control of the visible working conditions.

The Japanese management system has many advantages, and many of its features have been adopted also in the USA and in Europe. In the field of health and safety, at least two advantages can be distinguished. Firstly, the health and safety activities are integrated into the general continuous improvement processes carried out mainly in small teams in the lower levels of the organization. Secondly, employees are motivated because they feel they can use their abilities to the full extent. This in turn has led to increased overall effort on the employee's side, and through the continuous improvement schemes to increased productivity and better safety.

The literature surveys and the results of the case studies of this work support the described assumptions on the national differences. For example, the case studies showed that direct management involvement was at higher level among the companies in the USA than in Finland. Furthermore in the USA management sets more often goals to the safety activities, and accidents are investigated and analyzed more systematically than in Finland.

There are also some problems when national differences in industrial safety are studied. Accident statistics can have bias because of different reporting systems and different compensation practices. The lost day accident rate is influenced by the fact that in some countries the injured person can receive substitutive work. Even more bias can be found when absenteeism rates, occurrence of work-related mental problems, or untimely retirement rates are compared. High absenteeism rate can be due not only to unsatisfying working conditions, but also compensation systems can effect this phenomena. There are also national differences in how commonly mental problems are seen as a ground for disability to work. Finally, the pension system can have effect on employee's willingness to stay at work. The understanding of these national conditions and practices is essential when comparisons are done.

9.3 Limitations of the research methodology

The scope of this research was very wide. Studying safety management systems, and the auditing of these systems is a demanding task. Research of any complex system requires several studies, and in one study only some results can be obtained. The validation of the results is important, so that it can be determined whether the results are in line with the other studies in the field.

This research used case study methodology. The strength of this approach is that the data is collected from the real world, and thus it has a potential to be empirically valid. The problems of this work are related to the large scope of the research. Firstly, the number of the case study companies was limited to eleven. The reason for the low number was that each case study requires a lot of resources to carry out. Each audit requires preparation, interviews on-site, and reporting of the results. Secondly, selection of the companies influences the results to some extent. In order to find differences between the companies, they were selected from two countries, and the size of the companies varied from 30 employees to 2900 employees. It is difficult to say whether the companies represent the average standard in each country. However, it can be assumed that since the case study companies were willing to cooperate in the research, they were somewhat more active in health and safety issues than average companies.

9.4 Proposal for future studies

In the industrialized countries, it is more and more difficult to achieve improvements in health and safety. Accident frequencies decrease more slowly than before. Obviously some totally new methods are needed. New potential methods and practices include development of safety management systems, integration of health and safety to quality management systems, better understanding of the safety culture, striving towards zero accidents, improvement in the behavioral safety, and the concept of total safety. These are discussed in the following.

In the industrialized countries, health and safety cannot be improved anymore only by using engineering solutions. In many organizations, the next step has been the development of top management driven safety management systems. Currently also legislation (e.g. the Seveso II Directive in the chemical industry) and standards (e.g. the BS 8800) support this development.

One major trend in industrial companies is the integration of health and safety to other management activities. Many enterprises have included their safety policies and programs into their general activity procedures, for example, quality management system documents. The same development can also be seen with the environmental hazard management systems. The current standardization is in line with this development, and the new ISO 9001 (1999) quality management standard, the BS 8800 safety management standard, and the ISO 14001 environmental management standard are based on the same management principles.

The next major step in safety management can be the thorough understanding of *safety culture*. Booth and Lee (1995) have defined that the ultimate goal of safety management is the development of a positive safety culture. What is the mechanism that leads to this "positive safety culture" is, however, not thoroughly known. Another question is, how this culture is measured. Can a safety culture have a numerical value ? Furthermore, can we say that one culture is better than another ?

One current trend is the striving towards *zero accidents*. It has been observed in some studies that when an organization accepts a certain number of accidents annually, the efforts to prevent accidents begin only when the limit number is almost reached. According to the zero accident philosophy, the demand for zero accidents forces the organization to fight against accidents on a continuous basis.

According to several studies, 80 % to 95 % of all accidents are related to unsafe human behavior (Cooper 1998). *Behavioral safety* has been introduced as a methodology to decrease the unwanted human acts, e.g. conscious risk taking. The principles of behavioral safety are, in fact, based on older behavior modification and motivation theories which are now applied to safety. Typical solutions to change people's attitudes include safety campaigns, safety training, safety incentives, and in some cases disciplinary procedures.

One current trend is also the concept of *total safety*. This philosophy emphasizes that hazards should be identified in all surroundings where people live. This means that off-the-job safety, including safety at homes and in traffic should have the same importance as job safety. Today, ten times more people die in home accidents and in traffic than in occupational accidents.

10. Conclusions

This work had three hypotheses. In this chapter, it is discussed whether the results of the study support the hypotheses.

The first hypothesis claimed that the auditor’s expertise in health and safety, and in the safety legislation influences the reliability of audit results. It can be stated that based on the results of this study this hypothesis proved to be correct.

In an ideal situation, the audit results tell what the real safety activity level is in a company, and the results are the same irrespective of who the auditor is. In practice, the auditors knowledge on safety legislation, general experience on good safety practices, as well as thorough understanding of the company’s climate and culture influence the results.

In this study, the strength of agreement between the author and the companies’ observers was generally at a lower level than the strength of agreement between the author and the students. It can be assumed that the observers’ professional and cultural background influenced the results. The author and the students had the same cultural background, although the professional background was somewhat different. Compared to the company observers’, the author had greater cultural difference, and also professional background was unequal. Besides this, the author’s knowledge on the US health and safety legislation was not at very high level.

The second hypothesis claimed that a properly constructed audit tool can improve the reliability of audit results. This study supports also this hypothesis. By developing accurate activity criteria, the reliability of the audit results improves. However, the audit tool alone cannot ensure that the results are consistent. The auditor’s experience and background always influences the outcomes.

The D&S method seems to give low inter-observer reliability when the observers have different professional or cultural background, and high reliability when the background is equal. Thus, the study shows that in the use of D&S method, the audit results are greatly dependent on the quality of the auditor. The

MISHA method, on the other hand, gives more reliable results than the D&S method even when the auditor is not trained.

An audit method which has accurate activity criteria supports, in principle, high reliability compared to a semi-structured or an open method. This study did not completely support this assumption. The D&S included quite detailed activity criteria, but it did not ensure high reliability in all situations. However, reasonably high reliability was reached in the use of the MISHA method which was clearly a semi-structured method.

It can be concluded that the total reliability of an audit method is difficult to measure, because reliability is always influenced both by the audit method itself and the auditor. A high number of reliability tests would be needed before the influence of the method and the auditor can be separated from each other.

Statistical validity tests were not done in this work. However, the correlation between the audit findings and the accident types was analyzed when the MISHA method was tested. This analysis showed that an audit method can help an experienced auditor identify both primary and organizational causes for accidents. Furthermore, an audit tool does not necessarily help an inexperienced auditor. He can still miss some obvious weaknesses in safety activities, especially those related to the organization’s functioning.

The third hypothesis stated that safety activities are at higher level in the USA compared to Finnish companies when the D&S method is used as the assessment tool. This hypothesis also proved to be true. Especially some follow-up activities were clearly at higher level among the companies in the USA. Accident investigation was better arranged, as well as near-miss reporting procedures. Differences were found also in the safety organization, and in the management participation. The control of physical hazards was in quite high level in all companies.

There can be several reasons for the national differences. These include different overall management culture, different safety legislation, safety authority’s role, and different compensation systems. Further studies are needed in order to clarify the reasons in detail.

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Appendix A: Modified Diekemper & Spartz method used in the preliminary case studies in the USA and Finland

A. ORGANIZATION AND ADMINISTRATION

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
1. Statement of policy, responsibilities assigned.	No statement of safety policy. Responsibility and accountability not assigned.	A general understanding of safety, responsibilities and accountability, but not in written form.	Safety policy and responsibilities written and distributed to supervisors.	In addition to previous items, safety policy is reviewed annually. Responsibility and accountability is emphasized in supervisory performance evaluations.
2. Direct management involvement.	No measurable activity.	Follow-up on accident problems.	Active direction of safety measures. Management reviews all injury and property damage reports and supervises the corrective measures.	Safety matters are treated the same way as other operational parameters (e.g. quality or production design). Management is personally involved in safety activities.
3. Safety instructions to hazardous tasks.	No written instructions.	Written instructions to some of the hazardous tasks.	Written instructions to all hazardous tasks.	In addition to previous items, the instructions are available at the workplaces. Management ensures that employees follow the instructions. The instructions are regularly updated.
4. Workplace design.	Workplaces cannot be adjusted to fit various size of employees.	Workplaces are re-designed and modified when work inherited health hazards have been noticed.	Workplaces are easy to adjust for each employee.	In addition to previous items, human requirements are treated the same way as other design parameters in the design of work and workplaces.
5. Emergency and disaster control plans.	No plan or procedures.	Verbal understanding on emergency procedures.	The possible disastrous situations are surveyed using a suitable risk analysis method. Written instructions are made for these disastrous situations.	Responsibilities are defined, and the personnel is regularly tested and trained.

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
6. Plant safety rules.	No written rules	Plant safety rules have been developed and are available in the workplace.	Plant safety rules are incorporated in the plant work rules.	In addition to previous items, plant work rules are updated regularly.
7. Measurement of the safety activities.	Safety activities are not measured.	Safety committee or safety personnel gives occasional feedback of the activities.	Safety activities are measured systematically at least once a year. Activities are modified and improved according to the measures.	In addition to previous items, management follows the results of the measurements and takes part in the further development. Results are compared to the previously set goals. Some measurements are performed using an expert outside the company.
8. Safety organizational structure.	No specific safety organizational structure in existence.	Safety organizational structure exists, but has no significant activities.	Safety department or specific safety personnel makes an annual plan which consists of hazard recognition, accident investigation and regular safety surveys.	Safety department or specific safety personnel coordinates and/or follows production modifications and purchase of new machinery. Safety department or personnel works in company's internal development groups. Summaries of accidents are discussed. Summaries of the safety of work environment are made and discussed. Relations to line-management are good.
9. Health care.	Health care is not provided to employees.	Health care is formally arranged. Health surveys are partially made.	Health care personnel visits workplaces in order to find work related health hazards. Pre-employment examinations and other essential health surveys are made.	Systematic workplace surveys are made in order to find existing health hazards. Proposals for improving work environment are made. Health care personnel takes part to the training of new employees, makes some of the written operating procedures, and provides direct feedback to the employees.

B. INDUSTRIAL HAZARD CONTROL

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
1. Housekeeping – storage of materials, etc.	Housekeeping is generally poor. Raw materials, items being processed and finished materials are poorly stored. Unused handtools are lying on floors, etc.	Housekeeping is fair. Walking and working surfaces are mainly free. Some attempts to adequately store materials are being made. Tools are mainly properly stored.	Housekeeping and storage of materials are orderly. Walking and working surfaces are free. The status of housekeeping and storage is frequently followed.	In addition to previous items, employees are encouraged to keep working areas and other surfaces clean and free of obstacles.
2. Machine guarding.	Little attempt is made to control hazardous points on machinery.	There is evidence of control which meets applicable Federal and State requirements – but further improvement may still be made.	Machine hazards are effectively controlled to the extent that injury is unlikely. The conditions and usage of safety equipment is followed.	Safety aspects are taken into consideration in the design and purchase of new machinery.
3. General safety of work environment.	Little attempt is made to control such hazards as: unprotected floor openings, slippery or defective floors, stairway surfaces, inadequate illumination, etc.	Applicable Federal and State requirements are met. Further improvement can still be made.	Hazards are effectively controlled to the extent that injury is unlikely.	Safety aspects are taken into consideration in the design of work environment.
4. Maintenance of equipment, guards, handtools, etc.	No systematic program of maintaining guards, handtools, controls and other safety features of equipment, etc.	Partial, but inadequate or ineffective maintenance.	Maintenance program for equipment and safety features is adequate. Equipment are tested and inspected before issuance, and on a routine basis.	In addition to previous items, there is a preventive maintenance program for hazardous equipment.

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
5. Material handling – manual and automated.	Mainly manual material handling. Loads are heavy, difficult to handle, or material handling with irregular workload and high repetition.	Material handling is partially automated or mechanized.	There is very little manual material handling.	In addition to previous items, employee's physical capabilities are taken into consideration in the design of material handling systems.
6. Personal protective equipment.	Proper equipment are not provided or they are not adequate for specific hazards.	Proper equipment is provided.	Very hazardous tasks have special protective equipment. The distribution and use of the equipment is controlled by supervisors.	In addition to previous items, maintenance of the equipment is organized.

C. FIRE CONTROL AND INDUSTRIAL HYGIENE

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
1. Chemical hazard control references.	No knowledge or use of reference data.	Reference data is available in the company.	Reference data is delivered to foremen, and the data is used by the foremen when needed.	Data is available and posted in the workplace where it is needed. Employees have read and understood the contents of the data.
2. Storage of flammable and explosive materials.	Storage facilities do not meet fire regulations. Containers do not carry name of contents. Excessive quantities permitted in manufacturing areas.	All storage facilities meet minimum fire regulations. All containers carry name of contents. Containers are kept in approved storage cabinets.	In addition to previous items, supply at work area is limited to one day requirement.	In addition to previous items, storage facilities exceed the minimum fire regulations.
3. Ventilation – fumes, smoke and dust control.	Ventilation rates are below industrial hygiene standards in the exposure areas.	Ventilation rates in exposure areas meet minimum applicable standards.	In addition to previous items, ventilation rates are periodically measured, recorded and maintained at approved levels.	In addition to previous items, equipment is properly selected and maintained close to maximum efficiency.
4. Skin contamination control.	Skin irritable liquids and materials are widely used. Little attempt to control or eliminate exposure to skin irritants.	First-aid reports on skin problems are followed up on individual basis for determination of cause.	All employees are informed about skin-irritating materials. Employees provided with approved personal protective equipment or devices.	In addition to previous items, maintenance of the equipment is organized. Injury records indicate good control.
5. Fire control measures.	Do not meet minimum insurance or municipal requirements.	Meet minimum requirements.	Special permit needed for jobs having a fire hazard.	In addition to previous items, a fire crew is organized and trained in emergency procedures and in the use of fire fighting equipment.

D. SUPERVISORY PARTICIPATION, MOTIVATION AND TRAINING

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
1. Line supervisor safety training.	All supervisors have not received basic safety training.	All supervisors have received some safety training.	All supervisors participate regularly in safety training sessions.	In addition to previous items, specialized sessions conducted on specific problems.
2. Training of new employees.	No program covering the health and safety job requirements.	Verbal training only.	A written handout to assist in training.	Company has a trained instructor for new employees.
3. Job hazard analysis.	No hazard analyses made.	Job hazard analysis made on some jobs.	Job hazard analysis conducted for majority of operations.	Job hazard analysis performed on a regular basis and the results are used in workplace design, work instructions and in training of new employees.
4. Training for specialized operations (Fork trucks, grinding, punch presses, solvent handling, etc.)	No training for specialized operations.	Some of the employees have received adequate training.	Safety training is given for all specialized operations on a regular basis, and retraining is given periodically to review correct procedures.	In addition to previous items, training needs are regularly evaluated.
5. Internal self-inspections.	No program or activities to identify and evaluate hazardous practices and/or conditions.	Line supervisors or safety personnel make occasional safety inspections. No written program.	A written program outlining inspection guidelines, responsibilities, frequency and follow up is in effect.	Training is given for making the internal self-inspections. Inspection results are followed up by top management.
6. Safety promotion and publicity.	Safety issues are not promoted by any means.	Bulletin boards and posters are considered the primary means for safety promotion.	Additional safety displays, demonstrations and films are used on a regular basis.	Special displays are used regularly and are keyed to special themes.

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
7. Employee/ supervisor safety contact and communication.	Employees and supervisors do not discuss safety matters. Employees do not report the safety hazards they have noticed.	Employees and supervisors discuss the perceived safety hazards.	In addition to previous items, supervisors regularly cover safety when reviewing work practices with individual employees.	In addition to previous items, supervisors regularly review work safety requirements together with each individual employee.

E. ACCIDENT INVESTIGATION, STATISTICS AND ANALYSIS

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
1. Accident investigation by line personnel.	No accident investigation made by line supervision.	Applicable OSHA requirements for maintaining accident records are met. No program for accident investigation is in effect.	Line supervision is trained and makes complete and effective investigations of all accidents. The causes of accidents are determined and corrective measures are initiated immediately.	In addition to previous items, an investigation of every accident is made within 24 hours of its occurrence. Reports are reviewed by the department manager and/or plant manager.
2. Accident cause analysis and statistics.	No statistical analysis is made.	Accidents are statistically analyzed to some extent.	The results of the statistical analysis are used to pinpoint accident causes so that accident prevention objectives can be established.	In addition to previous items, accident causes and injuries are graphically illustrated to develop the trends and evaluate performance. Management is kept informed on plant safety status.
3. Near-accident investigation.	Near-accidents are not investigated.	Some of the near-accidents are investigated.	Written instructions for investigation of near-accidents are used.	In addition to previous items, management reviews the results of the near-accident investigations.

RATING FORM

	Level 1	Level 2	Level 3	Level 4
A. ORGANIZATION AND ADMINISTRATION				
1. Statement of policy, responsibilities assigned.	0	4	14	15
2. Direct management involvement.	0	4	18	20
3. Safety instructions to hazardous tasks.	0	2	8	12
4. Work workplace design.	0	2	6	8
5. Emergency and disaster control plans.	0	4	10	12
6. Plant safety rules.	0	2	4	5
7. Measurement of the safety activities.	0	4	10	12
8. Safety organization.	0	2	5	8
9. Health care.	0	2	5	8
Total value of circled numbers	_____ +	____ +	____ +	_____ x 0.2 = Rating ______

B. INDUSTRIAL HAZARD CONTROL

1. Housekeeping – storage of materials, etc.	0	5	16	20
2. Machine guarding.	0	5	16	20
3. General safety of work environment.	0	5	16	20
4. Maintenance of equipment, guards, handtools, etc.	0	5	16	20
5. Material handling – manual and automated.	0	3	8	10
6. Personal protective equipment.	0	3	8	10
Total value of circled numbers	_____ +	_____ +	_____ +	_____ x 0.2 = Rating ______

C. FIRE CONTROL AND INDUSTRIAL HYGIENE

1. Chemical hazard control references.	07	20	25	
2. Storage of flammable and explosive materials.	0	7	20	25
3. Ventilation – fumes, smoke and dust control.	0	4	13	15
4. Skin contamination control.	0	4	13	15
5. Fire control measures.	0	4	14	20
Total value of circled numbers	_____ +	_____ +	_____ +	_____ x 0.2 = Rating ______

D. SUPERVISORY PARTICIPATION, MOTIVATION AND TRAINING

1. Line supervisor safety training.	0	10	22	25
2. Training of new employees.	0	2	8	10
3. Job hazard analysis.	0	1	5	10
4. Training for specialized operations (Fork trucks, grinding, punch presses, solvent handling, etc.).	0	2	7	10
5. Internal self-inspections.	0	5	14	15
6. Safety promotion and publicity.	0	1	4	5
7. Employee/supervisor safety contact and communication.	0	5	20	25

Total value of circled numbers _____ + _____ + _____ + _____ x 0.2 = Rating ______

E. ACCIDENT INVESTIGATION, STATISTICS AND ANALYSIS

1. Accident investigation by line personnel.	0	10	32	40
2. Accident cause analysis and statistics.	0	10	32	40
3. Near-accident investigation.	0	6	16	20

Total value of circled numbers _____ + _____ + _____ + _____ x 0.2 = Rating ______

TOTAL RATING __________

SUMMARY

The numerical values below are the weighted ratings calculated on rating sheets.
The total becomes the overall score for the location.

A. Organization & Administration	___________________
B. Industrial Hazard Control	___________________
C. Fire Control & Industrial Hygiene	___________________
D. Supervisory Participation, Motivation & Training	___________________
E. Accident Investigation, Statistics & Reporting Procedures	___________________
TOTAL RATING	___________________

Appendix B: Modifications to Diekemper & Spartz method used for the preliminary case studies in Finland

The version used in the USA: The activity A4, and the criteria.

A. ORGANIZATION AND ADMINISTRATION

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
4. Workplace design.	Workplaces cannot be adjusted to fit various size of employees.	Workplaces are re-designed and modified when work inherited health hazards have been noticed.	Workplaces are easy to adjust for each employee.	In addition to previous items, human requirements are treated the same way as other design parameters in the design of work and workplaces.

The version used in Finland: The replaced activity A4, and the criteria.
The weighted values for the levels were the same in both versions.

A. ORGANIZATION AND ADMINISTRATION

Activity	LEVEL 1 (Poor)	LEVEL 2 (Fair)	LEVEL 3 (Good)	LEVEL 4 (Excellent)
4. Employee selection and placement.	Employee's health status is not examined before placement.	Only pre-employment physical examination given. This information is used in placement to some extent.	Employee's health status is examined and this information is used in the placement.	In addition to previous item, health status is followed on a regular basis and placement is reconsidered when needed.

Appendix C: Results of the assessment in Case X

A. ORGANIZATION AND ADMINISTRATION		AU	PM	SD	SR	SM
A1. SAFETY POLICY						
A1.1.	Written safety policy	3	2	1	1	2
A1.2.	Top management commitment	1	2	1	1	2
A1.3.	Goals of the policy	1	1	2	1	3
A1.4	Personnel's participation to the preparation of policy	3	2	3	1	3
A1.5.	Description of current organization and tasks	3	1	2	2	3
A1.6.	Areas of responsibility, authority, and tasks	0	2	1	1	1
A1.7.	Safety and health documents	1	2	2	1	3
A1.8.	Reviews and revisions of the policy	3	2	3	1	3
A1.9.	Informing and distribution of the policy	3	2	3	1	3
A1.10.	Informing outside the company	2	1	0	1	2
A1.11.	Connections to other company policies	0	2	1	2	1
A2. SAFETY ACTIVITIES IN PRACTICE						
A2.1.	Top management safety knowledge	2	1	1	1	1
A2.2.	Line management safety knowledge	1	2	1	1	1
A2.3.	Supervisor safety knowledge	1	2	1	1	2
A2.4.	Safety committee or other participatory safety team	1	2	2	1	3
A2.5.	Safety manager	2	2	2	2	1
A2.6.	Safety representative	2	2	3	2	3
A2.7.	Occupational health services	2	2	3	2	3
A3. PERSONNEL MANAGEMENT						
A3.1.	Planning of the personnel resources	3	2	3	2	3
A3.2.	Employee hiring and placement	2	2	3	3	2
A3.3.	Selection of supervisors	2	2	2	2	2
A3.4.	Opportunities for professional development and career	1	2	1	1	1
A3.5.	Resources for health and safety activities	2	2	1	2	2

B. TRAINING AND MOTIVATION		AU	PM	SD	SR	SM
B1. SAFETY TRAINING OF PERSONNEL						
B1.1.	Evaluation of safety training needs	2	1	1	1	2
B1.2.	Planning of personnel training	2	1	1	1	2
B1.3.	First-aid training	2	2	2	1	3
B1.4.	Record of the people with special training	1	2	0	2	2
B1.5.	Instructing employees to work	1	2	2	1	1
B2. WORK INSTRUCTIONS						
B2.1.	Preparing of the work instructions	1	2	2	1	1
B2.2.	Employee participation to the preparing of work instructions	1	2	3	1	3
B2.3.	Updating of the work instructions	2	2	3	1	2
B3. INCENTIVES TO SAFE WORK PRACTICES						
B3.1.	Feedback on performance from supervisors to employees	1	1	1	1	1
B3.2.	Cooperation between supervisors and employees	2	2	2	2	2
B3.3.	System to bring up initiatives	0	2	2	3	3
B4. COMMUNICATION						
B4.1.	Information dissemination system	2	2	1	2	3
B4.2.	Informing about changes in production and new technologies	2	2	3	2	3
B4.3.	Reporting of identified hazards	2	2	3	2	3
B4.4.	Safety campaigns	0	1	2	1	1
B4.5.	Safety material	2	1	2	1	2

C. WORK ENVIRONMENT

		AU	PM	SD	SR	SM
C1. PHYSICAL WORK ENVIRONMENT						
C1.1.	Identification of hazardous work tasks	3	2	1	2	3
C1.2.	Design of physical work and workplaces	2	2	2	2	2
C1.3.	Chemical hazards	1	2	2	1	2
C1.4.	Muscular work load	1	2	2	1	2
C1.5.	Noise and vibration	2	2	2	2	2
C1.6.	Illumination	3	2	3	2	3
C1.7.	Temperature	2	1	2	2	2
C1.8.	Mechanical accident hazards	2	2	3	2	3
C1.9.	Other accident hazards and hazards on the way to/from work	2	2	2	2	2
C1.10.	Maintenance	1	2	2	2	2
C1.11.	Plans for major accident situations	3	2	3	2	3
C2. PSYCHOLOGICAL WORK ENVIRONMENT						
C2.1.	Design of psychological work environment	0	1	0	1	1
C2.2.	Definition of employee responsibilities	2	2	1	2	2
C2.3.	Mental stress factors originating from the work task	2	1	2	1	2
C3. ANALYSIS OF WORK ENVIRONMENT						
C3.1.	Health and safety surveys	1	2	1	2	2
C3.2.	Tasks of occupational health service	1	2	3	1	3
C3.3.	Tasks of safety organization	1	2	1	2	3

D. FOLLOW-UP		AU	PM	SD	SR	SM
D1. OCCUPATIONAL ILLNESSES						
D1.1.	Setting of the goals	1	1	0	2	2
D1.2.	Statistics and reporting	2	2	0	3	2
D2. OCCUPATIONAL ACCIDENTS						
D2.1.	Setting of objectives	2	1	2	1	2
D2.2.	Statistics and reporting	2	2	2	2	3
D2.3.	Accident investigation	0	2	0	2	2
D3. OCCUPATIONAL DISEASES						
D3.1.	Setting of objectives	1	1	0	2	2
D3.2.	Statistics and reporting	2	2	1	2	3
D4. WORK ABILITY OF EMPLOYEES						
D4.1.	Physical work ability	1	2	1	1	2
D4.2.	Mental work ability	2	2	0	1	1
D5. SOCIAL WORK ENVIRONMENT						
D5.1.	Surveys on the social work environment	2	2	0	1	2

AU = Author
PM = Personnel manager
SD = Safety director
SR = Employees’ safety representative
SM = Safety manager

Appendix D: Results of the assessment in Case XI

A. ORGANIZATION AND ADMINISTRATION		AU	MD	MC	S	SR
A1. SAFETY POLICY						
A1.1.	Written safety policy	0	0	0	0	0
A1.2.	Top management commitment	2	0	0	0	0
A1.3.	Contents of the policy	0	0	0	0	0
A1.4.	Determination of responsibilities, authority, and tasks	0	0	0	0	0
A1.5.	Participation to the preparation of policy	0	0	0	0	0
A1.6.	Initial status review	0	0	0	0	0
A1.7.	Health and safety related documents	0	0	0	0	0
A1.8.	Review and updating of the policy	0	0	0	0	0
A1.9.	Informing and distribution of the policy	0	0	0	0	0
A1.10.	Informing outside the company	0	0	0	0	0
A1.11.	Connections to other company policies	0	0	0	0	0
A2. SAFETY ACTIVITIES IN PRACTICE						
A2.1.	Top management safety knowledge	2	1	2	1	1
A2.2.	Line management safety knowledge	2	2	2	2	0
A2.3.	Supervisor safety knowledge	2	2	2	2	1
A2.4.	Safety committee or other participatory safety team	1	2	2	3	2
A2.5.	Safety manager	2	2	2	1	2
A2.6.	Safety representative and other employee representatives	2	2	3	1	2
A2.7.	Occupational health services	3	3	3	3	2
A2.8.	Resources for health and safety activities	2	2	3	2	2
A3. PERSONNEL MANAGEMENT						
A3.1.	Planning of the personnel resources	2	2	2	2	3
A3.2.	Employee hiring and placement	2	1	2	2	3
A3.3.	Selection of supervisors	1	2	2	1	1
A3.4.	Opportunities for professional development and career	1	0	2	0	0

B. PARTICIPATION, COMMUNICATION, AND TRAINING		AU	MD	MC	S	SR
B1. PARTICIPATION						
B1.1.	Cooperation between supervisors and employees	1	1	2	2	0
B1.2.	Employee participation to the design of work and workplaces	1	1	2	1	0
B1.3.	Small-group activities	0	0	1	0	0
B2. COMMUNICATION						
B2.1.	Information dissemination system	2	1	1	1	1
B2.2.	Informing about changes in production and new technologies	2	1	1	2	0
B2.3.	System to handle initiatives	0	2	2	0	0
B2.4.	Safety campaigns	0	1	2	0	0
B3. SAFETY TRAINING OF THE PERSONNEL						
B3.1.	Evaluation of safety training needs	1	1	2	1	0
B3.2.	Instructing of new employees	1	1	1	2	0
B3.3.	Preparing of the work instructions	1	1	2	0	0
B3.4.	Work permits to hazardous tasks	2	3	3	1	3

C. WORK ENVIRONMENT		AU	MD	MC	S	SR
C1. PHYSICAL WORK ENVIRONMENT						
C1.1.	Design of physical work and workplaces	1	2	2	0	0
C1.2.	Chemical hazards	1	2	2	2	3
C1.3.	Muscular work load	0	1	2	3	2
C1.4.	Noise	1	2	2	2	2
C1.5.	Illumination	1	1	2	1	2
C1.6.	Temperature	1	1	2	2	2
C1.7.	Accident hazards and hazards on the way to/from work	1	2	3	2	2
C1.8.	Maintenance	1	1	2	1	2
C1.9.	Major accident hazards	2	2	2	2	3
C2. PSYCHOLOGICAL WORK ENVIRONMENT						
C2.1.	Design of psychological work environment	1	2	2	1	0
C2.2.	Mental stress factors at work	1	1	2	1	2
C2.3.	Definition of employee responsibilities	1	0	2	1	0
C3. ANALYSIS OF THE WORK ENVIRONMENT						
C3.1.	Workplace hazard analyses	1	0	2	2	2
C3.2.	Tasks of occupational health service	1	3	3	*	2
C3.3.	Tasks of the safety organization	2	1	2	1	2

*) the observer was not able to determine the score

D. FOLLOW-UP		AU	MD	MC	S	SR
D1. OCCUPATIONAL ACCIDENTS AND ILLNESSES						
D1.1.	Occupational accidents	2	2	3	1	2
D1.2.	Accident investigation	2	2	2	0	0
D1.3.	Occupational illnesses and absenteeism from work	2	2	2	1	0
D2. WORK ABILITY OF EMPLOYEES						
D2.1.	Physical work ability	2	1	3	0	0
D2.2.	Mental work ability	2	1	2	0	0
D3. SOCIAL WORK ENVIRONMENT						
D3.1.	Surveys on the social work environment	1	1	1	0	0

AU = Author
MD = Managing director, also safety manager
MC = Maintenance chief
S = Supervisor
SR = Employees' safety representative

Appendix E: The MISHA audit method – Version II

A. ORGANIZATION AND ADMINISTRATION

A1. Safety policy

A1.1. Written safety policy

- Does the company have a written safety policy ?
- Are the personnel aware of the policy ?

A1.2. Top management commitment to the safety policy

- Has company's top management (factory manager, managing director) committed itself to the goals of the policy ?
- Is the commitment visible in management's everyday activities ?

A1.3. Contents of the policy

Does the policy have the following elements ?

- the role and importance of safety to the company
- a description of the company's safety goals
- the main safety activities and procedures
- a description of the organization and administration of the safety activities
- a description of the safety tasks and responsibilities

A1.4. Assignment of tasks and responsibilities

Are the tasks and responsibilities assigned to:

- the top management ?
- the line management and the supervisors ?
- the employees ?
- the safety and health personnel ?

A1.5. Participation in the preparation of the safety policy

Have the following personnel groups participated in the preparation of the safety policy ?

- the top management
- the line management and supervisors
- the employees
- the safety and health personnel

A1.6. Initial status review

Were the following aspects reviewed before the policy was prepared ?

- what is the current health and safety level in the company ?
- what are the typical and potential hazards in the company ?
- is the current safety management system operating effectively ?

A1.7. Safety documents

Does the policy list the following documents ?

- work instructions
- instructions for safety training
- instructions for training of new employees
- instructions for line-managers' and supervisors' safety duties
- safety organization's activity program
- health service personnel's activity program

A1.8. Revising the safety policy

Has the company defined:

- how often the policy is revised ?
- who are responsible for revising the policy ?

A1.9. Dissemination of the policy

Has the company defined:

- how the policy is made available to the personnel ?
- how new employees can access the policy ?
- how the revised versions of the policy are distributed ?

A1.10. Informing external bodies about the company's safety policy

Has the company defined:

- how temporary workers, sub-contractors, clients, authorities, and other external bodies can have access to the company's safety policy ?
- who inform these external bodies about the policy ?

A1.11. Safety policy's connections to company's other activities

Has the company considered how the safey policy is linked to:

- the company's quality policy
- the company's environmental policy

A2. Safety activities in practice

A2.1. Top management's safety knowledge

Is the top management aware of:

- how well the company's premises and equipment meet the health, safety and usability standards ?
- how health and safety is considered in the design of new workplaces and processes ?
- what the satisfaction, motivation, mental well-being and social relationships are among the personnel ?
- what is the safety performance of the line-management and the supervisors ?
- what are the costs of occupational accidents and illnesses ?
- what is the trend in the company's insurance costs ?
- what is the cost-effectiveness of the safety activities ?

A2.2. Line management's safety knowledge

Is the line management aware of:

- what is the housekeeping standard of the plant ?
- whether the safety training procedures are adequate in the company ?
- what is the safety standard of machines, equipment and tools ?
- what is the quality of the personal protective equipment ?
- how employees use and take care of their personal protective equipment ?
- what is the employees' risk behavior (conscious risk taking) ?
- how to find safety expertise from inside or outside the company ?
- how safety and health aspects are taken into account in the design of new workplaces and processes ?
- how health and safety aspects are taken into account when new machines or equipment are purchased ?

A2.3. Supervisor’s safety knowledge

Are the supervisors aware of:

- what is the housekeeping standard of the plant ?
- what are the safety training procedures in the company ?
- what is the safety standard of the machines, equipment and tools ?
- what is the quality of the personal protective equipment ?
- how employees use and take care of their personal protective equipment ?
- what is the employees’ risk behavior (conscious risk taking) ?
- how to find safety expertise from inside or outside the company ?
- how health and safety aspects are taken into account in the design of new workplaces and processes ?
- how health and safety aspects are taken into account when new machines or equipment are purchased ?
- what are actions to be taken in an emergency situation (serious injury, fire, etc.) ?

A2.4. Safety committee and/or other cooperative safety team(s)

- Does the company have a safety committee or some other cooperative safety teams ?
- Does the committee/team have both employer and employee members ?
- Does the committee/team prepare an annual working program for itself ?

A2.5. Safety manager

- Does the company have a safety manager ?
- Has the safety manager received adequate safety training ?
- Does the safety manager have adequate time and other resources for the safety activities ?

A2.6. Safety representative and/or other personnel representative(s)

- Have the employees elected a safety representative (when required by law) ?
- Has the representative received adequate safety training ?
- Does the representative have adequate time and other resources for the safety activities ?

A2.7. Occupational health services

- Does the company provide occupational health (OHS) services for all its personnel ?
- Are the OHS personnel well acquainted with the company's organization and functions ?
- Are the OHS personnel aware of the health and safety hazards typical to the company ?

A2.8. Resources

- Does the company assign special resources to health and safety activities on an annual basis ?
- Does the company seek advice from health and safety personnel when determining the resources ?

A3. Personnel management

A3.1. Planning of the personnel resources

Are there short-term and long-term plans for:

- the number of needed personnel resources ?
- the future production systems and work processes ?
- how the business activities can change in the future ?
- how the elderly personnel's work ability is ensured ?
- actions in the situation where the company has to down-size ?

A3.2. Selection and placement of the personnel

Has the company defined:

- who participates to the selection of new employees ?
- which are the selection methods and criteria used ?
- the rules for rotating personnel in the different tasks ?

A3.3. Selection of line management and supervisors

Does the selection include evaluation of the candidates

- leadership qualities ?
- ability to evaluate how the personnel copes with the work ?
- ability to motivate personnel ?
- ability to identify health and safety hazards ?
- ability to handle problems related to the human relations ?

A3.4. Promotion, rewards and career planning

Has the company defined:

- how the personnel's quality of work is measured ?
- what is the relationship between the quality of work and rewards ?
- how individual career planning is done ?

B. PARTICIPATION, COMMUNICATION, AND TRAINING

B1. Participation

B1.1. Supervisor/employee communication

- Does the supervisor follow and give feedback on employees' quality of work ?
- Does the supervisor instruct employees in safe work practices ?
- Are there regular supervisor/employee discussions on the employee's career development ?

B1.2. Employee participation into the workplace design

- Are employees' opinions and suggestions asked when the work processes and work environment are (re)designed ?
- Do employees participate to projects were the work processes and work environment are (re)designed ?

B1.3. Development in teams

- Has the company established small groups with employee participation for developing the work ?
- Are these groups effectively managed, and are they working actively ?
- Do these groups have the necessary management support and resources ?

B2. Communication

B2.1. General communication procedures

- Are the personnel aware of the company's communication practices ?
- Does the management arrange information meetings for all personnel on a regular basis ?
- Is the communication from the employee level to the upper organizational levels effectively arranged ?
- Are the wall-boards, internal leaflets, e-mail, etc. effectively used ?
- Are the new employees instructed for the communication practices ?
- Are the personnel aware of the hazard reporting systems ?

B2.2. Information on changes

- Are the personnel informed adequately and in advance on the new work practices and procedures ?
- Are the personnel adequately informed on the potential hazards associated to the changes in the work ?

B2.3. Suggestions for improvements

- Is there a systematic procedure for collecting employees' suggestions ?
- Are the personnel encouraged to make suggestions ?
- Do the personnel know the procedure for how to make the suggestions ?
- Are the suggestions evaluated promtly ?
- Is feedback provided to the person who made the suggestion ?
- Can the person who made the suggestion complete it afterwards ?
- Are the best suggestions rewarded ?

B2.4. Campaigns

- Does the company arrange health and safety campaigns ?
- Do the campaigns focus on potential hazards ?
- Is the campaign material up-to-date ?
- Is it possible to use external experts in the campaigns ?

B3. Personnel safety training

B3.1. Safety training needs

- Is the need for safety training evaluated on a regular basis ?
- Can the employees participate in the evaluation of the safety training needs ?
- Are the supervisors able to estimate the need for safety training ?
- Does the safety training cover all personnel groups ?
- Has the need for first-aid training been evaluated ?

B3.2. Training for work

- Are the persons responsible for giving the training defined ?
- Are all employees, including temporary workers, trained for their work ?
- Is the experience of the senior workers used in the training ?

B3.3. Preparing of the work instructions

- Has the company defined which work instructions are necessary ?
- Are there written work instructions for all hazardous work tasks ?
- Are the work instructions available at the workplace or otherwise easily obtainable ?
- Have the employees seen the instructions, and can they operate according to them ?
- Have the employees and supervisors participated in the preparation of the instructions ?
- Are the instructions revised regularly, and are the old ones removed ?

B3.4. Work permits

- Has the company defined which work permits are necessary ?
- Is the training for the use of work permits planned and realized ?
- Does the company keep a record of the persons with permanent work permits (e.g. permit to do fire hazardous work) ?

C. WORK ENVIRONMENT

C1. Physical work environment

C1.1. Design of the physical work and workplace

- Are the workplace designers trained for considering health and safety aspects ?
- Do the designers consult with the employees ?
- Do the designers consult with the supervisors, and the health and safety organization ?
- Are accident risks considered in the design of workplaces and work processes ?
- Is ergonomics, e.g. working postures and other physical actvities considered in the design of workplaces and work processes ?

C1.2. Chemical hazards

- Does the company have a system for distributing and updating the material safety data sheets ?
- Are industrial hygiene measurements done on a regular basis ?
- Does the company have instructions for the handling and storage of hazardous chemicals ?
- Does every package and container of chemicals have the content identification attached ?
- Are the personnel trained for the handling and use of chemicals ?
- Are the personal protective equipment suitable, and are their availability and maintenance arranged ?
- Is there a system for using the least hazardous chemical when possible ?

C1.3. Physical loads

- Have the heavy physical material handling tasks been eliminated by automation or other means ?
- Has the company minimized the number of monotonous physical tasks, one-sided motions, and rapid repetitive motions ?
- Are the working postures ergonomically acceptable ?

C1.4. Noise

- Have the areas where the Threshold Limit Value (TLV) is exceeded been clearly marked ?
- Does the noise disturb communication, observations or concentration ?
- Are the personal protective equipment suitable, and are their availability and maintenance arranged ?

C1.5. Illumination

- Has the company ensured that the quality of illumination is suitable in the different work tasks ?
- Have reflections, dazzle, and contrast been considered in the planning of illumination ?
- Has the need for local spotlights been considered, e.g in quality control ?
- Can senior persons increase the level of illumination in their workplace when necessary ?

C1.6. Thermal conditions

- Is the temperature of the workplace appropriate considering the nature of the work ?
- Is the air flow effectively controlled ?
- Is the humidity effectively controlled ?
- Does the company provide suitable clothing for the personnel in abnormal thermal conditions ?
- Have the seasonal differences been taken into account in the design of the cooling/heating system ?
- Does the work include adequate number of breaks in uncomfortable thermal conditions ?

C1.7. Accident hazards

- Are floors, tables, racks, etc. in order and clean ?
- Are walkways in good condition, are their surface clean and free, are they marked, and are safety rails in place ?
- Are walkways separated from the driveways ?
- Are the machines and equipment in good condition, and are the safeguards in place ?
- Is the safety of motor vehicle traffic ensured ?
- Is the safety of travelling between home and the workplace promoted ?

C1.8. Maintenance

- Is the maintenance of machines and equipment at adequate level ?
- Does the compay have a preventive maintenance program for machines/equipment ?
- Is the regular cleaning of the plant area adequately organized ?

C1.9. Major accident hazards

- Are fire hazardous tasks well planned ?
- Are explosives and fire hazardous chemicals properly stored ?
- Is the handling of explosives and fire hazardous chemicals properly managed ?
- Is the extinguishing system adequate, and is the placement of fire fighting equipment well planned ?
- Is the condition of the extinguishing system controlled on a regular basis ?
- Are emission of hazardous/harmful chemicals in control ?
- Does the company have plans for the evacuation of personnel ?
- Are the licences from the authorities for manufacturing, handling, and storage of hazardous materials in order ?
- Are hazards analyses and risk assessments made for identifying potential major accident hazards ?
- Is cooperation and communication with safety & fire authorities, and the people living in the neighborhood adequately organized ?

C2. Psychological working conditions

C2.1. Design of the psychological working conditions

- Is the work environment and the work process designed considering the psychological aspects ?
- Do the designers know the concepts of mental underload and overload ?

C2.2. Psychological stress factors

Are the following stress factors under control in the workplace:

- stress, due to inadequate planning or organization of the work ?
- monotonous work and repetitive work ?
- work with automated production lines, e.g. with conveyor belts ?
- work with constant need for attention, e.g. in a control room or in quality control ?
- working alone, in isolation from the other workers ?
- difficulties in decision-making, e.g. due to inadequate instructions ?
- other stress building factors, e.g. noise, illumination, and thermal conditions ?

C2.3. Definition of the personnel's responsibilities

- Are the personnel's responsibilities and authorities clearly defined ?
- Are the persons responsible for health and safety of other people, production losses, or the quality of work trained for their responsibilities ?

C3. Hazard analysis procedures

C3.1. Workplace hazard analysis

- Are systematic hazards analyses carried out on a regular basis ?
- Are the targets of the analyses systematically planned ?
- Are suitable and effective methods used in the analyses (e.g. checklists, observation methods, interviews, or questionnaires) ?
- Are industrial hygiene measurement included in the analyses ?
- Are the persons responsible for the analyses trained for the work ?
- Are the analysis results reported to the management ?
- Does the report lead to the preparation of an action plan ?
- Is the follow-up arranged in order to see whether the proposed corrections/improvements have been done ?

C3.2. Tasks of the occupational health services (OHS)

- Are the goals of the OHS activities discussed with the top management ?
- Do the OHS personnel prepare an activity plan on an annual basis ?
- Do the OHS personnel have skills and methods for analyzing hazards at workplace ?
- Do the OHS personnel follow the effects of their activities ?
- Do the OHS personnel report their activities to the company management ?
- Do the OHS personnel participate in employee training ?

C3.3. Tasks of the safety organization

- Are the goals of the safety organization’s activities discussed with the top management ?
- Do the members of the safety organization have adequate training ?
- Does the safety organization participate in safety analyses ?
- Does the safety organization handle the analysis reports in safety meetings ?
- Does the safety organization follow the effects of its activities ?
- Does the safety organization participate in employee training ?

D. FOLLOW-UP

D1. Occupational accidents and illnesses

D1.1. Follow-up of accident statistics

- Does the company make statistics on accident rates, and summaries on accident causes ?
- Are the statistics and summaries available for the top management, the line management, and the supervisors ?
- Are accident rates and trends presented to the employees, e.g on wall-boards ?
- Are the accident statistics used as reference when new goals for safety improvement are done ?

D1.2. Accident investigation

- Has the company defined who investigates accidents ?
- Has the company defined how soon the accident investigation has to be done ?
- Are all accidents that have injured a person investigated ?
- Are the near-accidents investigated ?
- Does the compay have a systematic investigation method in use ?
- Are the corrective actions done promtly in order to prevent similar accidents to occur ?

D1.3. Absenteeism

- Does the company make statistics on absenteeism rates, and summaries on absenteeism causes ?
- Are the statistics and summaries available for the top management, the line management, and the supervisors ?
- Are the statistics and summaries used as reference when new goals for absenteeism reduction are set ?

D2. Work ability of the employees

D2.1. Physical work ability

- Does the company measure employees' physical work ability on a regular basis ?
- Is the individual person's work ability compared to the person's physical work load ?
- Are those persons working under heavy physical stress under special follow-up ?
- Has the company a system for rehabilitation and/or finding a new task for a person whose work ability has decreased ?
- Has the company a system for redesigning the work or workplace of a person who has difficulties in coping with the work ?

D2.2. Psychological work ability

- Does the company measure employees' mental work ability on a regular basis ?
- Is the individual person's mental work ability compared to the person's work task or physical workplace ?
- Are those persons working under extreme mental stress under special follow-up ?

D3. Social work environment

D3.1. Assessment of the social work environment

- Does the company have a system for measuring social climate (e.g. climate surveys) ?
- Are corrective actions done immediately when problems related to social relations have been observed ?

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Title

Safety management systems
Audit tools and reliability of auditing

Abstract

Safety auditing is a systematic method to evaluate a company's safety management system. This work concentrates on evaluating the reliability of some safety audit tools. Firstly, the factors affecting reliability in auditing are clarified. Secondly, the inter-observer reliability of one of the audit tools is tested. This was done using an audit method, known as the D&S method, in six industrial companies in the USA, and in three companies in Finland. Finally, a new improved audit method called MISHA was developed, and its reliability was tested in two industrial companies.

The results of the work show that safety audit tools do not ensure reliable and valid audit results. The auditor's expertise in the field of health and safety is particularly important when the company's compliance with the legal requirements is evaluated.

A reasonably high reliability in the use of the D&S can be achieved when the auditor is familiar with the audit tool, the national legislation, and the company's culture. The MISHA method gives more reliable results than D&S when the auditor is not trained. On the other hand, it seems that the D&S is more reliable when the auditor is a trained expert.

Some differences were found between the companies in the USA and in Finland. The organization and administration of safety activities was at a somewhat higher level among the companies in the USA. Industrial hazard control, as well as the control of fire hazards and industrial hygiene were at a high level in all companies in both countries. Most dispersion occurred in supervision, participation, motivation, and training activities. Finally, accident investigation and analysis were significantly better arranged among the companies in the USA. The results are in line with the findings of the literature survey on national differences in safety management procedures.

Keywords

hazard control, safety audit, safety management

Activity unit

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