COST CALCULATION MODEL FOR WORK RELATED ACCIDENTS

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Abstract

The Bachelor´s Thesis is a study of the models for calculating the costs of accidents. The main aim was to customize a cost calculation model for the use of the target company. The solution was searched for by looking through some of the previous cost calculation models for work accidents, and from them choosing suitable variables for the model of Petroltecnica. As a result a model was made in Italian language that can be used in reporting accidents and calculating their costs.

The thesis project was done by going through the research results concerning the cost calculation models. Cost calculation was attached into an existing accident reporting form used by the company. Work related diseases were left out from the cost calculation model for the reasons of simplicity.

The Bachelor´s Thesis clarifies the background for the accident cost calculation. It also presents some possibilities for the use of costs information. An electronic form for accident reporting was made for the company. The cost calculation part was attached to this accident reporting form.

Theoretical background showed that a lot of research information exists about the costs of accident, but only a few practical examples or directly usable models exist. There is room for development and studies also in the use costs information. It was also noted that the accident cost calculation model needs to be customized for the using organization so that useful information is collected and used.

Keywords

occupational safety, cost calculation, accident investigation

Miscellaneous

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Tiivistelmä

Opinnäytetyössä tutkittiin onnettomuuksista aiheutuvien kustannuksien laskentamalleja ja tavoitteena oli räätälöidä niistä sopiva kohdeyrityksen käyttöön. Ratkaisua haettiin tutkien aikaisempia työtapaturmakustannuslaskentamalleja ja valitsemalla niistä sopivat muuttujat Petroltecnican mallia varten. Tutkimuksen tuloksena tehtiin malli italiaksi, jota voidaan käyttää onnettomuuksien raportoinnissa ja kustannuksien laskennassa.

Työ toteutettiin käymällä läpi työtapaturmien kustannuksiin liittyvää tutkimustietoa ja kustannuslaskentamalleja. Kustannuslaskenta liitettiin yrityksessä käytettävään työtapaturmien tutkintalomakkeeseen. Yksinkertaisuuden vuoksi kustannuslaskentamallista jätettiin pois työperäisten sairauksien käsittely.

Opinnäytetyö selvittää työtapaturmien kustannuksien laskennan taustoja ja käyttömahdollisuuksia. Yrityksen käyttöön laadittiin elektroninen työtapaturmien raportointi lomake, johon oli liitetty myös onnettomuuden kustannuksien laskenta. Kustannuksien laskentamallia testattiin viidellä yrityksen historiassa tapahtuneella tapaturmalla.

Teorian läpikäynnissä kävi ilmi, että työtapaturmien kustannuksista on paljon tutkimustietoa mutta vähän käytännön esimerkkejä tai suoraan käyttöön sopivia kustannuslaskentamalleja. Kehitettävää ja tutkittavaa olisi myös kustannustiedon käyttömahdollisuuksien kartoittamisessa. Huomattiin, että työtapaturmien kustannuslaskentamalli on usein räätälöitävä organisaation tarpeiden mukaan, jotta hyödyllistä tietoa saadaan kerättyä.

Avainsanat (asiasanat)

työturvallisuus, kustannuslaskenta, onnettomuustutkinta

Muut tiedot

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1. INTRODUCTION TO RESEARCH PROBLEM

Companies have traditionally developed their occupational health and safety systems according to the laws and decrees. The main goal in accident prevention has been the protection of the personnel and operation according to the law. However the developments in safety and in accident prevention can bring the company also some significant economic benefits. Industrial accidents and occupational diseases can be a major item of expenditure, especially for small and medium-sized businesses. Measuring the costs of occupational accidents and their evaluation can be a good tool for finding shortcomings and development sites. Problems of the cost monitoring and calculation are not in the complicated mathematical formulae but in the hidden indirect costs, which can be very difficult to find out or evaluate realistically.

The aim of this bachelors thesis project was to develop a tool for accident costs calculation and evaluation. Development work was made by comparing the existing research data and calculation models and selecting the most suitable for the target company. The calculation was supposed also to take into account the Italian legislation and local policy conditions. The tool was tested with the some of the accidents that had happened during the past five years in the client company Petroltecnica. The targets set by the developer for this tool was that it could be used as an aid in assessing new safety investments, their payback period and to make cost-benefit analysis. The thesis is focused on the direct costs of the accidents and the cost of diseases and lowered working capabilities have been left out for simplicity.

The client of this project Petroltecnica is an Italian medium-sized company offering environmental remediation and waste processing services. The company is headquartered in Rimini in a province of Emilia-Romagna.

2. PETROLTECNICA COMPANY PRESENTATION

Petroltecnica is a company that provides consulting services, technical-managerial assistance, cleaning and remedial actions related to environmental waste management. The company was founded in the 1950s by Danilo and Pompeo Pivi. Soon after its founding it began working with big oil companies gathering valuable competence and know-how. Petroltecnica has specialized itself in prevention of environmental damage and creating technologies for more effective waste management and environmental cleaning such as "Bruco"- robot that won Petroltecnica the Sodalitas Social Award in 2004 *"tying with Procter&Gamble, in the sector dedicated to socially and environmentally innovative products, gaining notoriety over companies such as ENEL, Unilever Italia, IBM Italia and TIM"*(see figure 1.).

FIGURE 1. Bruco Tank-Sweeper robot

Petroltecnica consists of seven operational units which are the following: tank unit, waste unit, environmental unit, industrial remediation unit, environmental emergency unit, special projects unit, and global service unit.

During the course of its operation Petroltecnica has worked with many international and well known companies such as API, ENI, Esso, ERG, Exxon Mobil, PPG, Polimeri Europa, Shell, Tamoil, Total Italia and many others.

Petroltecnica has a certified ISO 9001:2008 quality management system for the activities of the company such as: remediation of soils and aquifers affected by hydrocarbons, collection, transportation, storage and treatment of waste products, control, purification and draining of fuel tanks, video-inspections in gas and industrial plants, remediation of refineries and tanks, non-destructive testing using penetrating liquids on tanks, pipelines and deposits from gas products, environmental emergency assistance. The company also has ISO 14001 certified environmental management system covering mainly management and the treatment of wastes (Petroltecnica. n.d.).

3. INDUSTRIAL SAFETY IN FINLAND AND IN ITALY

3.1. The History of Industrial Safety in Finland

Health and safety considerations for wage earners in Finland began with the development of sawmill and textile industry in mid 19th century. The trade regulations in the years of 1868 and 1879 were intended to protect children and women against the dangers of industrial work. The labor protection regulation of the 1889 was the first regulation covering all industrial workers and it also had vague provisions for health protection work and accident prevention (Kämäräinen 2003, 9). Since the 1900s the safety legislation has been following the development of industrialization and the changes in the economic structure and labor organizations. In the 1973 labor protection was extended to all workplaces as a statutory activity. At that time it was still mainly concerned about technical safety issues and accident prevention. The changes in the working life brought new priorities in the late 1980s when mental health and the supporting of working capacity became more common in workplaces. Improving the quality of working life and good work practices became the objective of the labor protection work of the early 1990s. Also the economic incentives of the labor protection became more emphasized. Current work for development is based largely on the EC regulation and domestic research results (Salonheimo 2003, 4-6).

3.2. Industrial Safety in Finland now

In Finland according to the Ministry Of Social Affairs And Health occupational health and safety includes also the conditions and terms of employment, mental well-being, leadership and the effective management of organizations and productivity. The greatest responsibility is given to the employers and companies. Legal requirements

are done so that the employers have the duty to ensure safe working conditions and environment. This is very much like in the systems used all over the world. Notable for the Finnish occupational health and safety work is the affiliation with the trade and labor unions. The leading organization for industrial safety in Finland is the Ministry Of Social Affairs And Health. The priorities of occupational health and safety strategy of Ministry Of Social Affairs And Health are the maintenance and promotion of employees' work ability and functional capacity, prevention of occupational accidents and occupational diseases, prevention of musculoskeletal disorders, mental wellbeing at work, coping with work life, control over one's work (Ministry of Social Affairs And Health 2006, 4). Nowadays also the certified occupational health and safety standards such as OHSAS 18001, are affecting a lot on the development of these issues inside the companies.

In Finland the area of industrial safety has numeral organizations and agencies. Frequently their functions are overlapping. The other most notable organizations in Finland are Regional State Administrative Agencies, FIOH Finnish Institute of Occupational Health, TKK: The Center for Occupational Safety, Työsuojelurahasto: The Finnish Work Environment Fund, TUKES: Safety Technology Authority, and STUK: The Radiation and Nuclear Safety Authority Finland. (Ministry of Social Affairs And Health 2006, 14-17)

3.3. History of Industrial Safety in Italy

One of the first laws on the safety of workplaces was introduced in Italy in 1942 in the civil code and the first specific legislation on the subject dates back to the 1950s. Of particular importance were the Degrees of the President of Republic No. 547 of 1955, No. 303 of 1956 and the decree No. 164 of 1956 for construction. These decrees were very broad and comprehensive for occupational safety. The decrees were however unable to lessen significantly the accidents at work.

In the '90s, after the entry of Italy into the European Union also other European directives were taken into use.

The decrees the No. 626 of 1994 and No. 494 of 1996, required companies, contractors and employers to respect the earlier laws and to manage continuous improvement for working conditions. Concerned parties also had to introduce training and education for the employees and to the person responsible for security. The main novelty of the Legislative Decree no. 626 was the requirement of risk assessment by the employer and the introduction of RSPP (Responsabile del Servizio di Prevenzione e Protezione) which stands for the Manager of the Prevention and Protection. This is a professional security expert appointed by employer to manage and coordinate the activities of the protection of employees and prevention of accidents (Legge 626/94 2002). A new law for occupational health and safety no. 81 was made in 9.4.2008 and it replaces the old 626 (Legge 81 2008). It might be safe to say that the problems of Italian occupational safety hasn´t been in the legislation but in the implementation of the law.

3.4. Industrial Safety in Italy now

ISPESL (Instituto Superiore per la Prevenzione e la Sicurezza del Lavoro) National Institute for Occupational Safety and Prevention is a parent organization for the regional SPISAL (Servizio Igiene Sicurezza Ambienti di Lavoro) agencies that are in charge of controlling the hygiene and safety in workplaces. Other agencies working with the ISPESL are the European Agency (Italian Focal Point), ILO-CIS, WHP-Workplace Health Promotion (National Contact Office), World Health Organization (Collaborating Centre), Mediterranean Network for Training and Research in Occupational Safety and Health, Italian National Mesothelioma Register, National Network for the Prevention of Psychosocial Distress in the Workplace (National Institute for Occupational Safety and Prevention of Italy, 2010). Other important organization is INAIL: Italian Workers' Compensation Authority which works to reduce accidents at work, insurance workers involved in risky activities and to integrate

victims of work accidents back into the labor market (INAIL: Workers Compensation Authority 2001)

4. ECONOMIC INCENTIVES FOR SAFETY

Work related accidents cause costs not just to the company or the employee but to the society as a whole. Many of these costs are hard to even evaluate in economic means such as the social costs. For an individual employee an accident leading to an injury means pain and suffering, consequences to his family and possibly to lowered physical capacity. For a company an accident might mean production losses, increased premium and high direct costs (Greef & Mossink 2002, 13). For the society the work related accidents mean costs to the national economy. Krüger´s study (1997) of economic incentives, opportunities and problems of modern safety systems clarifies some of the relationships of the costs for work related accidents see figure 2 (Krüger 1997, 26-37).

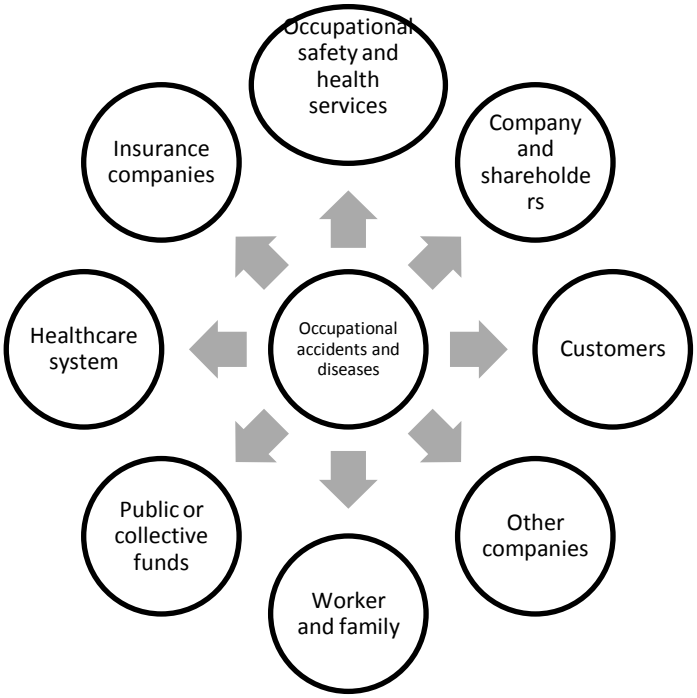

FIGURE 2. Relationship of costs of work related accidents. Adapted from Krüger 1997

Seeing the wide socioeconomic consequences it is no wonder that states and other legislative organizations have worked towards improving occupational health and

safety. Legislation and economic incentives have been found to be the two most effective methods to ensure continuous improvement in this area.

4.1. State Level Economic Incentives

Requirements coming from the law or the humane reasons are not necessarily the only motive behind working towards safe workplaces. Organizations are developing their safety systems for example reasons of: improving quality, working environment or lowering the costs of absenteeism. Some countries have taken systematic economic incentives in to use in order to improve working safety. In countries like France and Sweden it is possible to get support for the development of health and safety issues inside the organization. Also in Finland it is possible to get this support from the Finnish Industrial Safety Fund for safety training, informing about work safety and to the practical applications of industrial safety research studies. Also the costs coming from the occupational health care are compensated up to 50% (Salonheimo 2003, 7). Italian Workers Compensation Authority has a system of lowering the insurance premiums of organizations that are able to prove annually their improvement in occupational health and safety issues.

In European countries commonly economic incentives (or sanctions) are connected to the accident insurance premiums. In Finland the premiums are calculated by the classification of employees. There are 10 different responsible categories for employees and seven additional categories for certain large or special occupation groups such as building work or office work (If Vahinkovakuutusyhtiö Oy 2009, 8). In Finland after the company exceeds a certain amount of employees a special insurance payment method is applied. This way the company´s accident statistics are directly affecting to the insurance payments. This method might have also negative consequences for example outsourcing the most dangerous functions. For smaller companies the insurance payments depend from the national occupational accident statistics (Salonheimo 2003, 7). Early retirements can also be significant incentives for

the companies and countries to invest in occupational health and safety. *"In Finland the medium age for retirement is slightly under 60 and a large part of them are disability pensions"* (EU-OHSA 2009). Just in Finland some estimates say that early retirements cause the companies early costs of 3 billion euro (Aaltonen & Oinonen 2007, 62). In Finland the size of the company effects in the liability to pay for the disability pension can be seen in table 1.

TABLE 1. Effect of the company's size on the liability to pay disability pension in Finland. Adapted from Aaltonen and Oinonen (2007, 62)

Size of the organization	Payment liability
Organization with a staff of over 800 people	Pays the costs for disability pension completely.
Middle sized organization 50-800	The costs for disability pension are paid in joint responsibility with the common Employee Pension Scheme
Organization with a staff of under 50 people	The costs are paid completely from the common Employee Pension Scheme, because the costs would be too high even with one case of disability pension.

The Italian insurance premiums system is quite similar to the Finnish one. The employers are classified into four sectors with corresponding price lists and premium rates. The four sectors are industry, craftsmanship, services, and miscellaneous activities. In addition to these classifications the work is assessed by the risk involved. The more dangerous work is called "risky activity" and it affects the paid premiums by the employer organization. INAIL´s (The Italian Workers Compensation Authority) system for premium payments require: the employer to declare the previous year salaries, to calculate premiums from the last year salaries, deduct social security rebates and the tax concessions and to pay the sum due to INAIL, which is the result of the premium advanced and the possible balance related to the previous year, in

one single payment or in installments (INAIL: Workers Compensation Authority 2001b). The greatest difference between the insurance systems of Italy and Finland seems to be the amount of responsibility placed on the employer and Italy´s slightly more complicated bureaucracy.

4.2. Company Level Economic Incentives

At company level the governing functions are usually done based on the legal and economic factors. Accident and disease prevention can have several motivators' including expenses, company image, humane reasons, legal and regulatory requirements (Aaltonen & Oinonen 2007, 56). The greatest expenses in work accidents come usually from the immediate stop in the production. Imagine a stop of one week in a big project with fines for delays such as in a paper mill. In the process industry such as paper mills nowadays the timetables of large projects are planned by the hours. Delay in such a project leads to huge costs for fines and payments for staff waiting to begin work. With an example such as this is easy to show the importance of safety for the business success. Despite of this according to Aaltonen and Oinonen (2007, 56) in order the management to get motivated in following safety costs the following conditions need to be met:

1. *"It must be possible to effect in the costs with own actions."*
2. *"There must be a clear link between the investments in security and gains from them."*
3. *"Time delay of the gains gotten from the security investment cannot be too long. The longer the delay the least motivating effect."*
4. *"The cost data must be accurate, believable and reliable."*

The decrease in insurance premiums is also a definite incentive for companies to improve their safety but there are many other economic benefits. Accidents and ill health result in several costs (O'Conor 2002, 36):

Costs covered by insurance

- suffered injuries, ill health and damage

Uninsuranced costs paid by the company

- time lost for the accident
- extra wages, overtime payments to catch-up with production
- sick pay
- delays in production
- fines
- loss of contracts
- legal costs
- damage to products, plant, buildings, tools, equipment
- clearing of the accident site
- investigation time
- excess on any claims
- loss of business reputation
- increased premiums

Intangible Costs

- possible bad effects on consumer loyalty
- damaged reputation
- reduced customer satisfaction
- customer migration

At company level the accident and disease prevention and safety investments can lower or prevent these costs. Investment in occupational health and safety induces also other benefits than reduction in costs. More importantly the benefits are directly related to the reduction of sick leave and improved working capacity (see Figure 3.)

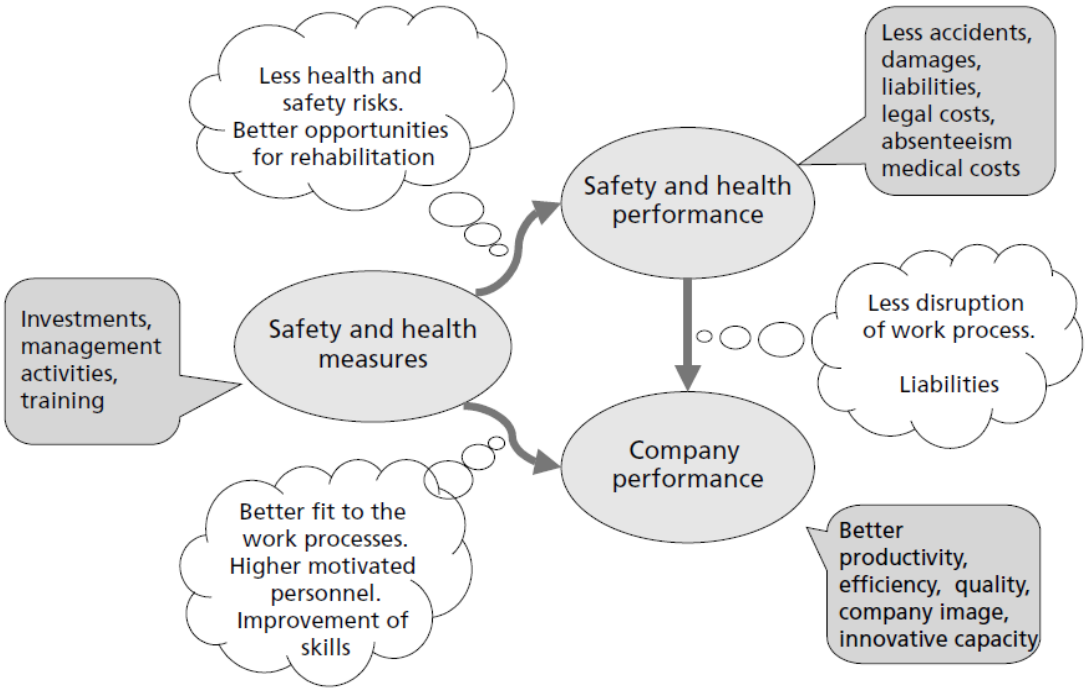

FIGURE 3. Economic effects on safety and health at company level. (Mossink 2002, 12)

The level of occupational safety might sometimes have significance to how well the company can market its products and services (Aaltonen & Oinonen 2007, 57). Not many companies want to make business with an organization with a history of serious work accidents. According to Aaltonen and Oinonen (2007, 57) the importance of occupational safety will increase in the future as the companies are more interested in the safety levels of their partners. One reason for this increased interested might be in the security management systems and standards that are implemented into use of the organizations. Insurance companies in the United States are working a lot to develop occupational safety in order to decrease the insurance payments. Similar work is also being done in Europe.

5. OCCUPATIONAL HEALTH & SAFETY STANDARDS

At the moment there is no European EN standard for the occupational health and safety management systems. However there is an international ISO-standard OHSAS 18001, which was previously a specification. The two most commonly recognized and used OHS management systems are OHSAS 18001 and the British BS8800. Also many national standards relating to occupational safety do exist.

5.1. OHSAS 18001 Standard

OHSAS stands for Occupational Health and Safety Assessment Series. OHSAS 18001 defines the requirements for effective occupational health and safety management system tool, so that the organization is able to control its OHS risks and to develop the level of its safety (Suomen Standardisoimisliitto SFS 2009). OHSAS 18001 standard was made in co-operation with several international organizations including: National Standards Authority of Ireland, Standards Australia, South African Bureau of Standards, British Standards Institution, Bureau Veritas Quality International, Det Norske Veritas, Lloyds Register Quality Assurance, National Quality Assurance, SFS Certification, SGS Yarsley International Certification Services, Asociacion Espanola de Normalizacion, International Safety Management Organization Ltd, Standards and Industry Research Institute of Malaysia and International Certification Services (OHSAS 18001 Health & Safety Zone 2007 Accessed on 19.2.2010). The OHSAS 18001 standard is based on the idea of filling the legal requirements and in the continuous improvement in occupational health and safety.

5.2. BS 8800

BS 8800 is a guideline to organizations for building a framework for occupational health and safety management. The guide can be used in organizations where the employees' health or safety might be affected (The BS8800 OHSAS and OSHA Health and Safety Management Group n.d. Accessed on 21.2.2010). Also the ISO 18001 occupational health and safety standard is based on the British BS8800. The goals of BS 8800 are to

> "*Minimize risk to employees and others by developing good working practices to prevent accidents and work-related ill health, improve business performance and assist organizations to establish a responsible image within the market place, assist organizations in continually improving their performance beyond legal compliance, help organizations to achieve compliance with its OH&S policies and objectives."*

It is published originally by the Health & Safety Executive of UK and the latest version is from 2004 (The British Standards Institution 2009). The weak point of BS 8800 might be its concentration solely on the British industry therefore for other countries it seems like a less tempting possibility. It could be recommended for companies and organizations that are making business with British companies.

6. RISK MANAGEMENT

Risk management for occupational health and safety is a systematic approach to prevention and planning to control hazards threatening employees, contractors, community residents and others that are exposed to them. In every activity that we do there is a possible risk. A good management is the one that is able to predict, eliminate and reduce these risks in its operational environment (Channing 2003, 173). There are several different approaches to risk management. According to Althaus disciple-based approach (2004, 2005) risk management is a multi-level discipline covering the fields of mathematics, human biology, economics and law all the way into to the more esoteric sciences that consider meta-debates on the notion of risk, including moral issues from philosophy and theology. This being said it is easy to imagine one getting lost in the jungle of academic pondering when looking for information on the subject (Clarke, Glendon & Mckenna 2006, 17). However the core processes of risk management simply put are:

1. Identifying all the possible hazards (what hazards are there? how many?)
2. Evaluating and estimation of risks caused by the hazards (how dangerous? how often they occur? who are exposed to them? are they within acceptable probability?)
3. Control of risks (methods of controlling? gained benefits?)
4. Monitoring controls (how are we succeeding? what changes to our system need to be done?)

The role of the organizations management is also to establish a culture that enables continuous improvement in health and safety. This is made by placing the core processes of risk management into use so that they affect the behavior of directors, managers, supervisors and employees in a way that harm is prevented. The process should also be tied together by company policy and their effectiveness measured by indicators, reviews and regular audits (Channing 2003, 178-180).

6.1. Identifying Hazards and Evaluating Risks

Risk identification is a process of determining the potential risks and hazards, their characteristics, duration and possible outcomes (Businessdirectory.com n.d.). Estimation and evaluation of risks is done after the potential hazards have been found. Risk estimation is commonly done by comparing the frequency and severity of the hazard, and as a result getting a risk level. The easiest way to estimate risks is to consider them as high, medium or low, in most cases this is the most convenient method. Sometimes weightings are used to emphasize the importance of either frequency or severity. Risk evaluation determines if found risk is tolerable or in need of corrective actions. The evaluating process is always subjective to the person who assessing the risks. The assessor is drawing to his experience, knowledge and ethics to make his judgment. According to Channing (2003, 179) much work has been done to put numerical probabilities for acceptable probabilities of risks. In the book Safety at Work Channing writes that (2003, 179) the following probability values for acceptable risk are presented:

- *”An acceptable risk of death for a single individual lies within the range of 10–3 to 10^{-4}.”*
- *”An acceptable risk of death for a group of individuals – a multicasualty incident lies within the range 10^{-5} to 10^{-6}.”*
- *”A risk of death can be ignored completely if it exceeds 10^{-7}.”*

Use of such chances is ethically controversial and they are a subject of constant change as working safety issues evolve (Clark 2001, 3).

6.2. Elimination of Risks and Risk Control Hierarchy

In order to eliminate risks there must be a strategic approach this is called the Risk Control Hierarchy. This hierarchy is an essential part of risk management ideology. According to Channing (2003, 180-181) Risk Control Hierarchy is a structured approach where for each hazard a set of options is considered. The goal is to minimize and eliminate the risks into the lowest reasonable level possible (The

University of New South Wales 2007). Various approaches to risk control hierarchy exist but the following points recur always in one way or another.

1. Elimination, the working method is changed or the substance is eliminated so that the hazard is removed. Used method shouldn´t lead to inferior product or less effective process.
2. Substitution, replacement of material or process with less dangerous one.
3. Reduction, faced risk is lessened by reducing the amount of materials held in the workplace.
4. Engineering solutions, using technical progress to reduce risks or installing additional equipment to control the risk.
5. Administrative control, reducing the time the employee is exposed to the hazard. Providing training and performing safety assessments.
6. Personal Protection Equipment, used after all the other options have been tried and found ineffective to control the risk. Employees must be educated to use the equipment.

After the elimination of risks the risk assessment has to be done again and see if new risks have been created and whether the elimination process has been truly successful.

6.3. Monitoring Controls

The aim of monitoring controls is to check whether OHS policy is being implemented, risk-control measures have been taken and lessons from previous experiences are put to use. Monitoring controls also provide feedback information to be used in reviewing and improving the safety performance (O´Connor & Everson 2002, 84).This has been the case specially when health and safety improvements and their performance are recognized and rewarded. Even so there has been some debate on whether economic incentives give good results in occupational health and safety performance. It is

important also to use other ways of measurement to get a good picture of the level of safety performance. Companies tend expect good results and are more willing to penalize for bad performance than to give incentives for appropriate development. This tends to depend on the organizations type and organization culture (Boardman & Lyon 2006, 42).

Traditionally the most common indicators of health and safety controls have been the accident rates, injuries and LTIR-lost time injury rates. However it is to be noted that low rates in accidents and injuries doesn´t mean that the accidents will be avoided also in the future. This is a concern especially in the companies that tend to have low probabilities of risks but major hazards are possible (O´Connor & Everson 2002, 85-86) (FHWA 2007). Nowadays the organizations willing to be successful in OHS issues are using preventive measurements instead of the reactive measurement for example: near miss situations etc. Responsibility for the health and safety measures should be with the organizations management. This has been seen to reinforce the commitment to health and safety improvement in work places. According to the United Kingdom´s Health and Safety Executive A Guide to Measuring Health & Safety Performance (HSE 2001, 10) effective risk control is done by measuring the following three elements see figure 4.

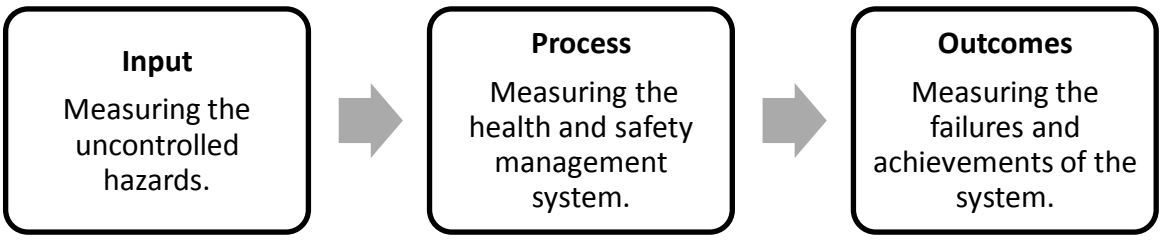

FIGURE 4. Risk Control measuring.

7. ECONOMIC EVALUATION OF SAFETY PERFORMANCE

Majority of companies have little or no existing direct information about their costs of occupational health and safety. To show the cost effectiveness of the organizations safety management system there is a need to be able to quantify the costs of the losses caused by accidents. The cost effectiveness can be shown by comparing the cost of accidents with other business costs such as production, sales or marketing to see the total economic losses caused by them. The use of economic indicators such as the cost-benefit analysis is helpful in deciding where to invest in safety and health.

The traditional approach to accident costs modeling is to develop a model for recording the accident costs of company. The average results of chosen period are then used in order to estimate the costs for the future. The aim has been in showing the significance of these costs to the upper management. The early research of occupational accident costs applied the *market-pricing model.* In this method the analyst writes down "*the actual losses due to accidents for different production factors such as lost working hours, materials and production."* (Kjellén 2000, 61). These variables are then evaluated in monetary units by applying the market-prices for each variable. The same approach was selected for the developed model of this bachelors thesis work. The cost of lost working hours, for example, is set as equal to the hourly wage of the accidents victim (Kjellén 2000, 61). The pioneering academic *of market-pricing model* method was Herbert William Heinrich. He was also the one to first to make distinguishing between direct and indirect costs. The other much used method is called *the accounting model,* which studies the impact of the accidents to the company's contribution margin (Matson 1998). *The accounting model* is closely related to the cost-benefit analysis methods described in the chapter 7.1. A closer study in these two models reveals that there isn´t so much difference in the used cost variables (figure 5). *The accounting model* has slightly less detailed approach to measuring the costs of lost work than the *market-pricing model,* it doesn´t take either the possible capital costs (for machinery etc.) into consideration.

Market-pricing model	*Accounting model*
• Lost work hours, victim	• Increased costs for personnel (replacement, overtime, etc.)
• Work hours spent on changing work routines	
• Work hours spent on the investigation	
• Work hours spent on repair of damaged equipment	
• Lost work hours due to interrupted production or reduced productivity	
• Costs of replacing damaged material	• Costs of replacing damaged material
• Costs for transportation (of victim etc.)	• Costs for transportation (of victim etc.)
• Capital costs (for machinery etc.) during production stop	
• Insurance expenditures	• Insurance expenditures
• Loss of income	• Loss of income
• Costs of safety measures	• Costs of safety measures
• Company's costs for medical treatment	• Company's costs for medical treatment

FIGURE 5. Company cost variables of Market-pricing and Accounting model. (Kjellén 2000, 62)

To understand all the different costs the pioneer of occupational health and safety H.W Heinrich developed an ice-berg diagram (FIGURE 6.) showing the relation between direct and indirect costs.

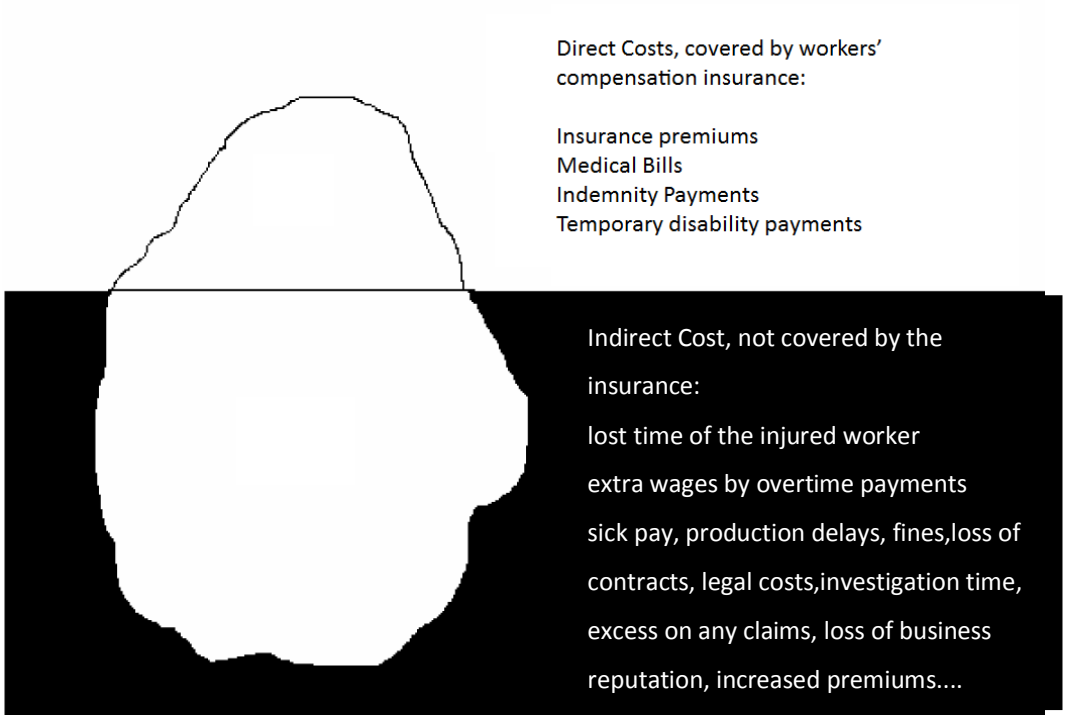

FIGURE 6. H.W Heinrich direct and indirect costs

Just by looking at Heinrich´s diagram it is easy to understand that the costs that most management considers as cost of safety constitute only a fraction of the total costs. In his studies Heinrich found that the indirect cost were about 4 times higher compared to the direct costs (Heinrich 1980). Later in 1960s Frank Bird took also the equipment damages into consideration and got a ratio of indirect costs six times higher than direct costs.

> "*However, later studies of accident costs in Britain, Finland, Israel, Norway and USA, applying variations of Heinrich and later accident cost models, have come to other results. The ratio between direct/insured costs and indirect/ uninsured costs vary from less than one to over 10*(Kjellén 2000, 62)".

These differences in ratio were explained by Kjellén (2000, 62): "*Differences in the applied methods and between industries and countries may explain the varying results.".*These ratios are good for getting the general idea of the magnitude of indirect costs but in order to get reliable and useful data it is necessary to use more specific methods of calculation. It is important also to notice that indirect and direct costs can be separated to insuranced and uninsuranced costs like done first in the 1950s by Grimaldi and Simons (Grimaldi & Simons 1975). The costs that are

interesting for companies are the uninsuranced ones, because they are the ones to be paid.

The mere amount of different indirect cost factors seems to make the calculations complicated. Several models for calculation have been done and some these are presented in a review made by the European Agency for Safety and Health at Work (Gervais, Pawlowska, Kouvonen, Karanika-Murray, Broek & Greef 2009, 26-30). The ones published in English are:

- The TYTA Model made by the European Commission (EC)
- Economic Assessment Tool by Niven K. published in *Occupational Health Review*, Vol. 88, 2000
- Annual Accident Cost Calculator and Incident Cost Calculator, by the Health and Safety Executive (HSE). 2005
- The Productivity Assessment Tool, published in *Journal of Safety Research,* 2005, Vol. 36, No. 3
- The ORC Return on Health, Safety and Environmental Investments (ROHSEI), published in *Journal of Safety Research*, 2005, Vol. 36, No. 3
- Value Principle for investment in occupational health, published in *Occupational Medicine*, Vol. 51, No.8, 2001
- Tool Kit (TK), *Journal of Safety Research*, 2005, 36(3)

These models provide valuable information for organizations willing to implement assessment tools for cost-benefit analysis, however each of these models require modifications according to the using organization. The calculations for the total costs of accidents are rather simple after the appropriate data is collected. According to Hammer and Price (2001, 6) total costs of an accident can be calculated with the following simple formulae:

$$TC= TC+C+D+I+L+N+O+R+W$$

Where the letters stand for:

TC=total costs

C=accident prevention cost

D=legal costs

I=immeasurable

L=immediate losses due to accidents

N=insurance

O=other safety costs

R=rehabilitation and restoration

W=welfare

The difficulty that all the organizations face is the identifying, gathering and analyzing all the needed data for calculations. The simplicity is vanishing after starting to ponder the variable ”*other safety costs*”. Hammers book describes the other costs as all the indirect costs coming from the accident. H.W Heinrich ice-berg diagram (FIGURE 6.) has shown us that these indirect costs are in fact several different ones and usually difficult to find out. The variable ”*immeasurables*” seems to refer to the humane suffering of the accidents, which of course is difficult or even impossible to measure by monetary terms.

7.1. The Cost –Benefit Analysis (CBA)

While the arguments towards tight control of occupational health and safety issues seems compelling, in most cases it´s necessary to balance the potential costs and benefits coming from the expenditure on safety measures. There are several ways to do cost-benefit analysis for different variables of accident costs. The two most commonly used methods are generic payback period (PP) and the ratio between the sum of all costs and the sum of all benefits that is called the cost-benefit ratio (C/B). The payback period is amount of time in which the investment is earned back. In the

industrial companies this payback time is usually around 3 years. The smaller the cost-benefit ratio, the better is the investment. In more advanced analytic methods is possible to calculate other indicators like the return on investment (ROI) in which also the depreciation is taken into consideration (Greef & Mossink 2002, 27).

To balance the costs, the potential costs and the benefits coming from safety measures expenditure the break-even point is a good tool for assessment. O´Conor (2002) presents a simple graphic illustration that compares the economic costs coming from control measures and failure of sufficient control (FIGURE 7). The more important thing to notice here is that after the so-called ”break-even point” (marked with B in figure 7) the expenditure doesn´t contribute anymore towards the reduction of work-related accidents, at least as much as before the break-even point. At the break-even point also the total costs for optimized accident prevention are at their lowest value. For each company and each accident this break-even point is different and it must be calculated case by case. Calculation of the break-even point can be done by comparing the economic information about the costs of accidents and the costs of safety improvements to the development of accident statistics of the company.

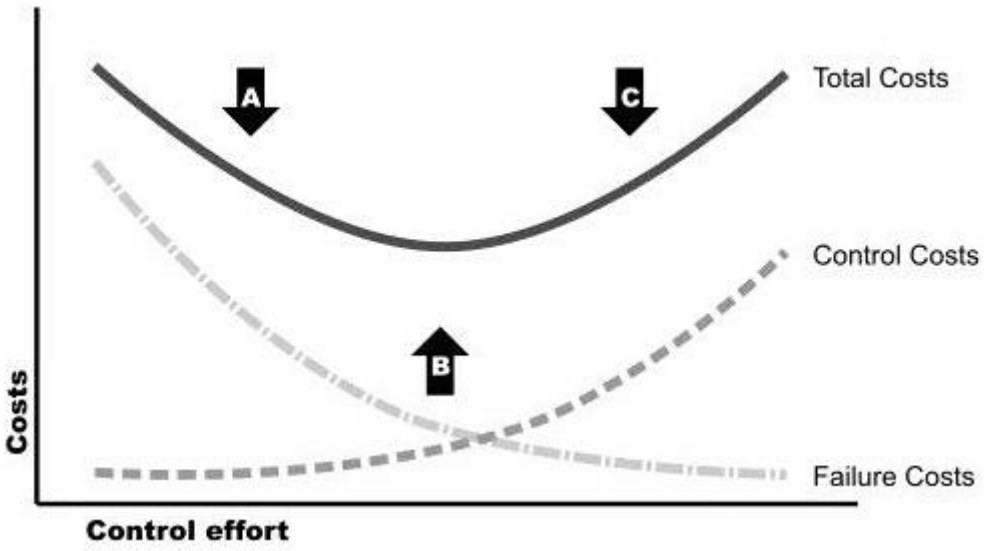

FIGURE 7. Control efforts and the break-even point.(O'Conor & Darren. Managing Health and Safety. p.37)

O´ Connors and Darrens (2002, 37) study shows also that a small increase in safety measure costs (marked with A in figure 7) is leading to a proportionally much greater reduction in failure costs. In figure 7 the C marks that the control costs are raising in significantly faster pace than the failure costs are falling, so also the total costs of accident prevention are rising.

7.2. Limitations of Cost-Benefit Analysis

The cost-benefit analysis (CBA) relies completely in the management's ability to quantify the economic costs and benefits. But how we can assess these two variables realistically? How can the management estimate the costs and benefits of something that is unknown? Some help for estimation can be gotten from previous experiences or national and EU reports. Still the CBA method remains as an imprecise science; it´s based on an assumption. Other thing is that CBA requires some minimum level of consensus. When talking about cost and benefits we first have to establish who is paying and who is benefitting? The same principle applies to the notion of risk and its acceptance. The risk of exposure to chemicals feels different for a manager sitting in an office than for an employee actually handling the chemicals in his daily work. If the cost-benefit analysis method is to be used effectively we need to have some amount of consensus about risks, hazards, accidents, costs, benefits and etc. Secondly for some people putting a price tag on a risk seems also an ethical question. For many quantifying the costs might not be seen as the best way of accident prevention. Although investing in accident prevention can be seen as acceptable. It´s up for the management and security personnel to decide whether CBA is to be used for its positive options or rejected for it´s somewhat controversial aspects.

Ethical questions are not the only ones without answers in cost-benefit analysis method. It is almost impossible to estimate the interconnectedness between the

work related accidents and illnesses caused by them. The other difficult thing to estimate is the importance of social factors. There exists some evidence (Cárcoba 1999) that suggests a link between higher probability of work related accident and ill-health when outsourcing and contracting is involved. A case also much related to the work of the client company in this thesis project. Petroltecnica´s projects are mainly work outsourced by other companies. This means that also the hazards of the work are outsourced for Petroltecnica and its OHS management system. It is to be noted that Petroltecnica and other similar companies are specialized in the management of hazards so the "outsourcing" of danger can many times be a beneficial solution for all parties.

Cost-benefit analysis can be used in a company of hundred employees but what about the other hundred contracted employees or even a thousand subcontracted or in temporary contracts? This is where the outsourcing of risks comes as an issue. The companies pass on the costs to society involving workers with atypical contracts. Cárcoba (1999) suggests in his article in European Agency of Health and Safety at Work Magazine that cost benefit analysis should take into consideration the penalties or compensation for any externalized costs. Although the cost-benefit analysis has its flaws so do all other systems. CBA is still one of the most practical ways of evaluation for investment in occupational health and safety. It is also a necessity in most small and medium sized companies where investments outside the core-business functions need to be made carefully and with maximum benefits.

8. CREATING A COST CALCULATION MODEL FOR PETROLTECNICA

The main aim of this thesis was to create a practical tool for assessing the costs of work related accidents. The original plan included also the strategic and humane costs. After through search, it became quite clear that only in economic costs the solely use of quantitative methods was possible. Other "costs" like strategic and humanitarian affects needed qualitative methods for evaluation. The assessment of economic costs was decided to be integrated with accident reporting. This would ensure that the economic costs assessment would be done always when accident was to be reported. The strategic costs were eventually left out from this thesis and more concentration was put into economic and so called humane costs.

The information for the evaluation of economic and humanitarian costs was collected from several sources. The most important sources of information were found to be UK Health & Safety Executives material, Net-cost model for workplace interventions published in *Journal of Safety Research vol. 36*, The Productivity Analysis Tool by M. Oxenburg and P. Marlow (2005, 209-214) and the extensive research material from the Finnish Institute of Occupational Health.

8.1. Model for assessing the economic costs of work accident

Studying the previously published models for accident costs calculation it was noticed that the greatest stumbling stone of them was going too much into details or on the other hand models that weren´t specific enough. The problem with the existing models was also the amount of variables for calculation. While it is true that the real scenario is complicated, there are also important reasons the models should be kept fairly simple all the while striving to be realistic at the same time. First thing is that a model with too many fill-able variables probably won't be used. For an example

Lahiri, Gold and Levensteins Net-cost model (2005, 241-255) had sixty-nine variables just to do CBA analysis to buy office chairs. How many of us has gotten a survey in his e-mail and after crossing options for few minutes has became bored and stopped the survey? A model that will be used needs to be simple and easy to use and take the minimum amount of time to fill. Next thing is that the existing models expected that the organizations were collecting information about many details not relating to their business. Obviously quite a lot of tweaking was needed that an appropriate amount of variables was found. The model was wanted to be made so that it was describing the costs realistically and that a minimum amount of estimations was to be needed when filling out the form.

The different cost variables were divided into five categories. The division was adapted from UK Health & Safety Executives (1997) *"The costs of accidents at work"* it was used to clarify different cost areas for the models user. Other two used resources for the variables were from the *"Inventory of socioeconomic costs of work accidents"* by the European Agency for Safety and Health at Work (Mossink & Greef 2002) and *"Työterveys ja työturvallisuus tuottavuustekijänä"* by the Finnish Institute of Occupational Health (Aaltonen & Oinonen 2007). The five categories for variables were: actions immediately after the accident, investigation of the accident, business costs, restarting the operations and sanctions and penalties. In addition to the five categories of cost variables a part was made for the costs that had to be either estimated or had a clear sum that could be extracted from bills see figure 8.

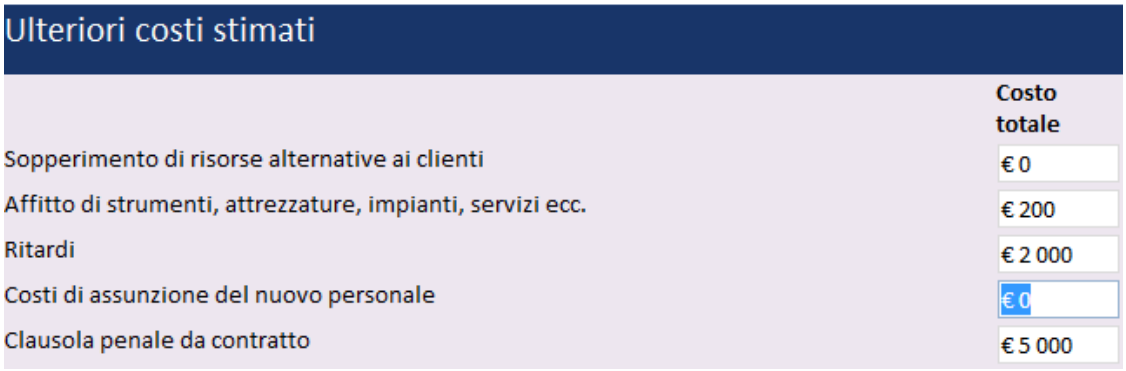

FIGURE 8. Screenshot from the part of costs evaluation.

The first part of the accident costs calculations model was made in so that two fields were to be filled for each item. These two fields were ”*Time spend*” and ”*Cost per hour*” and the product of these two variables would indicate the *”Total cost”* for each item see figure 9.

Costi per il tempo perso			
Infortunio (azioni immediate)	Tempo (h)	Costo (€)	Costo totale
Messa in sicurezza del personale e dell´area	2,5	30	€ 75
Downtime immediato del personale			€ 0

FIGURE 9. Screenshot from calculation of the product of two variables.

Actions immediately after the accident category first had four variables but they were then narrowed down to two: securing the people and area and immediate downtime of the personnel. This was done for two reasons. In an accident situation it is highly unlikely that anyone from the personnel involved would remember the situation so clearly that he could point out exact time for actions. Secondly there isn´t much difference in the cost of actions involved in the accident situation (securing personnel, first aid etc.). The less detailed approach to this category of costs can be compensated with adjusting the ”*Cost per hour*”-variable slightly higher than normally.

Investigation of the accident variables were left pretty much as they were presented in the HSE *The costs of accidents at work.* The four variables were:

1. Staff time to report and investigate accident
2. Meetings to discuss incident etc
3. Time spent with local Health & Safety authority

4. Consultant fees to assist in investigation

Noticeable about these variables is that most probably the greatest weight will be on the staff time to report and investigate. This will take the most time and has the most people involved from different areas of company.

Restarting the operations category is consisted of five variables. Restarting work included organizing and things needed to start working again. In the testing phase of model it was understood that it might difficult to input for example the time spend in cleaning the site or recovering work if there weren´t any existing procedures that ensured these things to be written down or memorized in some other way. This just shows that all data collection attempts inside a big organization require also other procedures than just creating a form for data storage.

Business costs were a category where it was wanted to put all the costs related to salaries and of the hiring of new personnel. In a normal scenario it is quite rare that a new person would be hired for the duration of sick leave of the victim of accident. These kinds of problems are most likely to be handled with reorganization of work. Reorganization of work affects the immediately in the working environment because it usually requires other personnel to take up the work of the person absent from work. A great increase in the workload has negative effects in the moral and the efficiency of work and it has also been connected to making more mistakes than usually. Reorganizing has many costs and to include them all or to name them is a difficult task. In the evaluation phase of these costs it might be useful to scale the estimation upwards in order to take also the hidden costs into consideration.

Sanctions and penalties category was to describe the legal costs that might rise up from accident situations. Originally also the increase in insurance premiums was one of the variables but it was removed because it wasn´t possible to calculate them by

the company. Increase or decrease in insurance premiums is gotten from INAIL so it is impossible to allocate this cost in one particular case of accident.

8.2. The form for accident reporting

The client company used a Microsoft Excel based table to collect information about accident happened at work. The information that was collected was the names of the people in the accident, location of accident, time of happening, cause of accident, description of accident and the amount of days the person was absent from work due to the accident. The reporting form (called Registro Infortunati) was made according to the requirements from INAIL (Italian Workers Compensation Agency). The company also had two forms for accident investigation and near miss- investigation.

8.2.1. Investigative process and root-cause analysis

The investigative process used a root-cause analysis that was loosely based on Robert Magers and Peter Pipes method (figure 10). However the used method was much simpler than the original method seen in the flowchart. The root cause analysis used by Petroltecnica used the *5 Whys* –method to discover the root causes. Special attention was given to the human based factors of accidents.

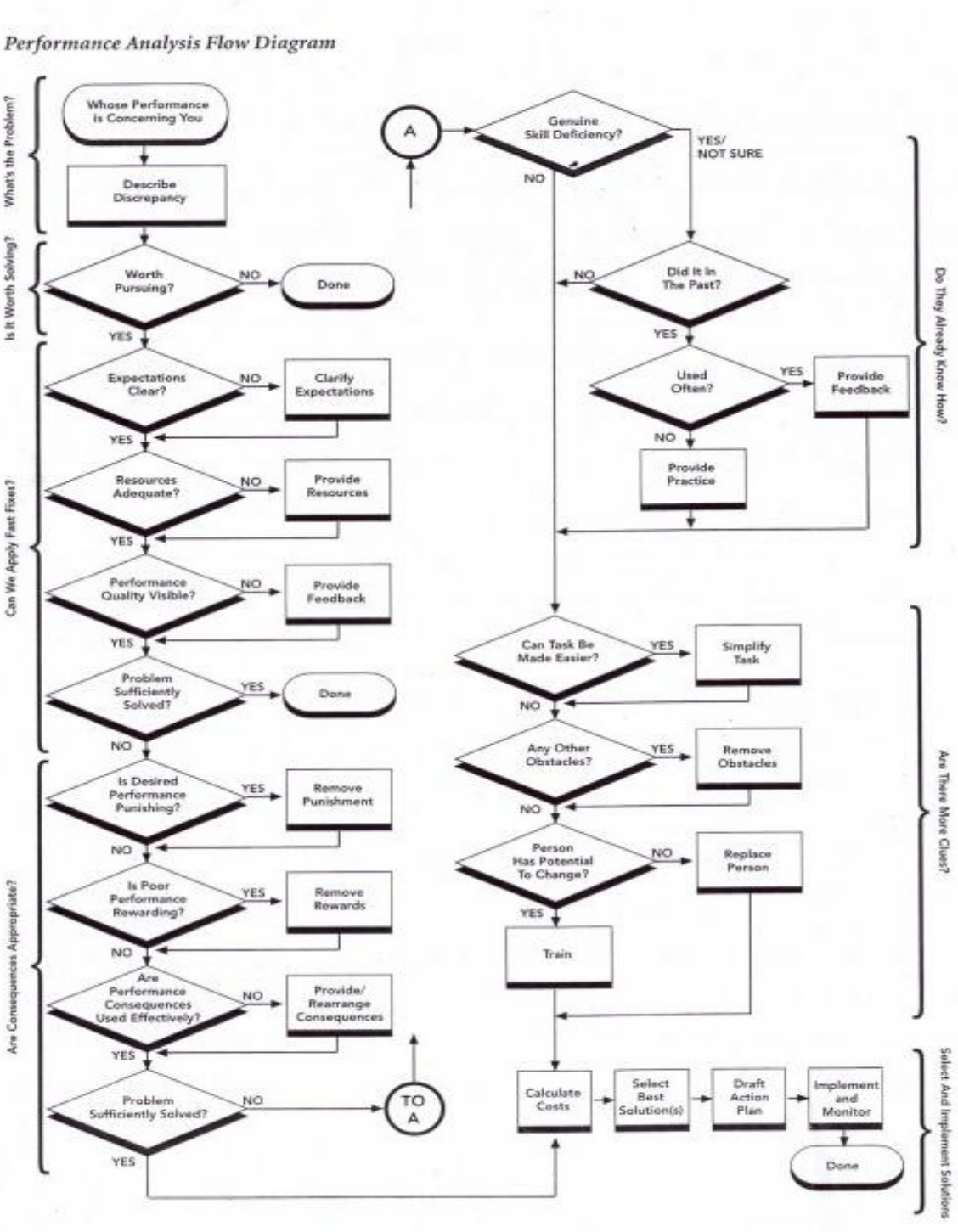

FIGURE 10. Mager Pipe flowchart. (Mager, Robert, Pipe & Peter 1997)

According to the Italian law the occupational accidents have to be reported within 48 hours to the local occupational health and safety officials and the police station. Accident has to be recorded also to the accident reporting form (registro infortunati). Accident investigation is not part of the requirements coming from the Italian

legislation; however it seemed like a good idea to attach the cost assessment to accident reporting and investigation. The original forms for accident reporting and investigation were Microsoft Excel and Word based applications. The requirements for the form for example automatically filled salary information led to the choosing of Microsoft InfoPath in the design of the form (see chapter 9. Tools – Microsoft InfoPath 2007).

8.2.2. Collecting and using the data of accident consequences

Information on the immediate consequences on the victim of an accident are usually quite easy to fill out and their nature is well-suited for classification. There are standardized schemes for the classification of injuries and part of the body affected. Table 2 shows an example of one of these standardized classification methods (Kjellén 2000, 58).

TABLE 2. Classification of consequences. (Kjellén 2000, 59)

Type of injury	*Part of the body*
• Contusions, bruises • Concussions and internal injuries • Open wounds, including cuts, lacerations, abrasions, severed tendons, nerves and blood vessels • Amputations • Open fractures • Closed fractures • Dislocations • Distortions, sprains, torn ligaments • Asphyxiation, gassing, drowning • Poisoning, infections • Burns (including chemical burns), scalds, frostbites • Effects of radiation • Electrocutions • Other	• Head, including facial area, eyes, ears and teeth • Neck • Back • Torso and organs, including rib cage, chest area, pelvic and torso • Upper extremities, including shoulder, arm, hand, fingers and wrist • Lower extremities, including hip, leg, ankle, foot and toes • Other part of body • Whole body and multiple sites

This method is from a publication of European Union´s statistical office Eurostat. The method was also adapted in the accident reporting form see figure 11. This made sure that the collected information was commensurate and consistent to other sources.

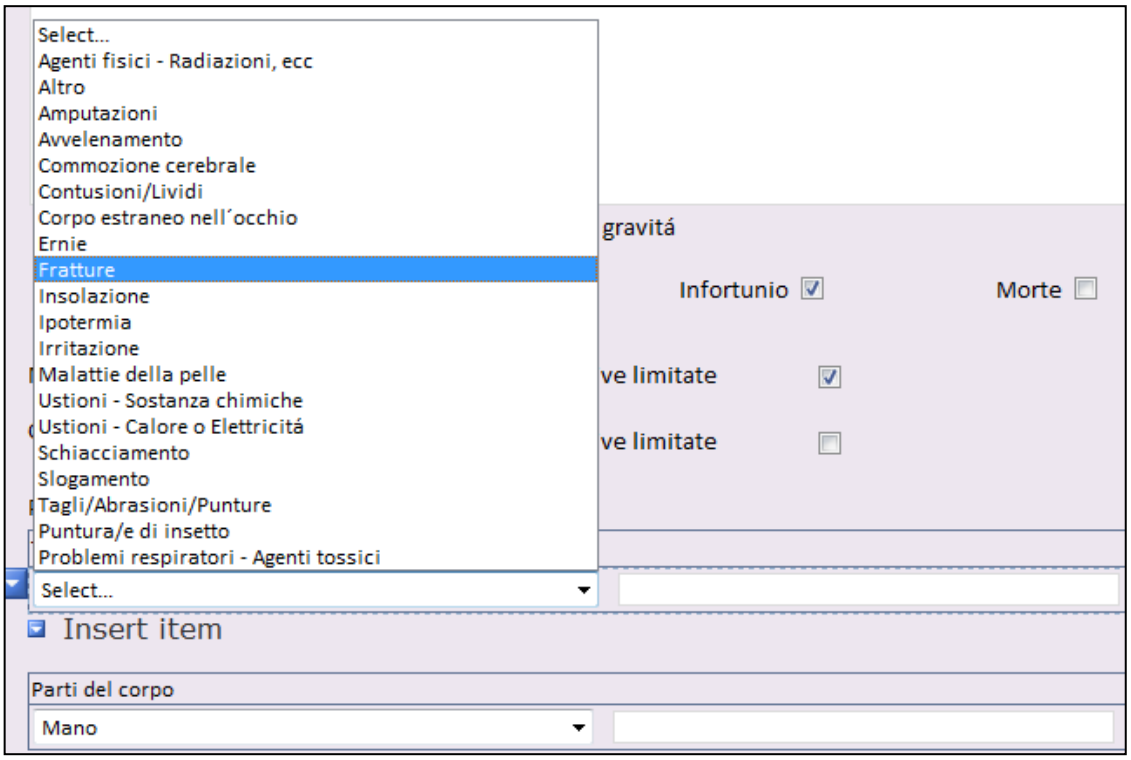

FIGURE 11. Classification of accidents in the new form.

Statistics of accident classifications can have many useful applications for example to determine good safety and health investments. One example of this practice is presented in Urban Kjelléns book of Prevention of Accidents Through Experience Feedback (2002, 59).

> *”Example: The yearly accident-statistics summary from a mechanical workshop showed that 25 per cent of the injuries were burns or cuts in the eyes. It was decided to introduce mandatory eye protection while working in the production halls in order to reduce this type of injury.”*

It might also be beneficial to classificate the environmental conditions of the accidents. This however is not usually done due to difficulties in identifying the

damage. This is also the case in classification of social or political losses due to accidents (Kjellén 2002, 59).

8.3. The humane costs for the victim of occupational accident

One of the greatest difficulties of this project was to determine the humane costs for the victim of the accident. Although the original goal of the project was to make model for calculating the monetary costs it was agreed that the greatest victim of accident is always the individual suffering from the accident. Accidents and occupational diseases always cause pain and discomfort, but also economic losses. It is very difficult to evaluate these consequences in monetary terms and it´s impossible to price a loss of health (Aaltonen 1980). To evaluate the economic consequences it is possible say that short sick leaves are not usually causing big monetary losses. On the other hand an accident at work can cause really significant economic challenges for the person and his family. The greatest loss for the victim is always the physical and mental pain which is caused by the accident, but it also creates economic consequences depending on the level of injury and duration of it. Also it can said that when the duration of sick leaves gets longer the significance of cost effects increases (Euroopan elin ja työolojen kehittämissäätiö, 1997). The different affects for sick leaves might be for instance:

- Change or effect in the career development
- Change to individuals life-style
- Costs of distances to health services
- Income level is tied to the salary level of the moment of incident
- Increase in living costs caused by exigencies of the situation
- Increased use of health care services
- Loss of earnings from secondary job
- Medical expenses
- Physical and mental affects
- Possible wage losses caused by the extended leave from work

It is notable that sick leave of absenteeism from work caused by accident also effects in the relationships between the employee with his colleagues and employer. Also the work that he will continue in the future will be affected in a loss of productivity that is caused by the subconscious effects of past accident. Nowadays much talk is put to the length of peoples working careers. Many European countries such as France and Finland at the time of writing this report are considering changes to the minimum age of retirement. This of course puts significance to the enjoyment and coping at work. The negative effects caused by illness or accidents are not helping with this. Premature transition into retirement will also cause loss of income for the individual. (Aaltonen & Oinonen 2007, 68-69)

9. TOOLS FOR THE MODEL

A wide range of tools for accident reporting and cost calculation form was considered. Firstly a mistake was made by not checking enough well the Microsoft licenses that the client company had and made a system using Microsoft InfoPath 2007 software. Secondly misleading advertisement on the Microsoft's webpage got us thinking that the form could used by the company without even having a license to InfoPath software. After doing all the work presuming Petroltecnica had the program we were forced to change the program used to fill out and design the data collection system. Because of this finally Acrobat Pro 9 was used to create fill able form to collect the needed data to test the calculation model. However both form types Acrobat´s pdf and InfoPath's xsn have the same data fields with slight differences in the usability. With small modifications it was believed that the data collection form could be used in any kind of organization interested in controlling and gathering data about their work related accidents.

9.1. Microsoft InfoPath 2007 and XML

Microsoft InfoPath 2007 is a part of the 2007 Microsoft Office system and it is designed to both fill out and design electronic forms. The program is based on Extensive Markup Language (XML) which is a set of rules in order to encode documents electronically. Benefits of XML include:

- content in a more uniform storage format
- avoidance of content errors
- facilitation of information retrieval
- automation of processing steps
- improved longevity of information
- facilitation of integration between other systems

- SEPA and XML messages, typically in between transfer of data between companies

At the time of this project the company didn´t have needs for accident reporting system integration with other systems, but the possibility of it was considered positive. According to the Microsoft's (MS) internet page at least the following technologies are working with InfoPath: InfoPath Forms Services, MS Office Excel, MS Office Outlook, Microsoft Office Access, MS Office Word, MS SQL Server, MS Windows SharePoint Services, MS Office SharePoint Server 2007, MS Script Editor, MS Visual Studio 2005, web services and Oracle databases and XML Schemas. When designing a form with Microsoft InfoPath the template of it is saved as .xsn file, which is a so called cabinet file that contains the files needed to form functions such as XML schema and XSL transformation files. When the users of this form template fill out the data it will be saved as industry-standard file XML. The greatest benefit of this is that only internet browser is needed to fill out the form, which means less needed licenses for Microsoft Office software (Microsoft 2010). This is where the work was mislead greatly because in order to fill out the form without InfoPath the form must be used remotely using a server with InfoPath installed. The Microsoft InfoPaths wide range of options made it a great tool for controlling data, but unfortunately in the end the project needed to be done using different method.

9.2. Acrobat Pro 9

Adobe Acrobat Pro 9 is software developed by Adobe Systems. It is designed for reading, designing and managing files in Portable Document Format (PDF). In this project the trial version of Acrobat Pro was used to design a form using the previous form made in InfoPath as a basis. Unfortunately there wasn´t any compatibility between these two software´s but with a minor tricks it was somehow possible to use the already made form. The greatest benefit of using Acrobat Pro 9 and Portable Document Format (PDF) was that the form could be actually used without having

Acrobat Pro 9 software. Much like the Microsoft´s InfoPath software Acrobat Pro 9 could also be used to manage data, which would seem like a good idea also for the client company of this project. It is just so much easier to manage all those documents using one of these tools. Decreased time in archiving and signing the documents might also cover all of these costs of license for the software. One benefit of using Acrobat was also the easier usability and comparison of old and new data.

10. TESTING THE COST CALCULATION MODEL

In order to determine the usability and reliability of the model a series of tests were made. The goal was to determine the strengths and weaknesses of the developed model. It was decided that model was to be tested with five cases of accidents that had happened in the client company's past. In all of the cases of accident the victim was out from work more than three days which is a limit for a minor accident in ESAW- system. It was however noticed that for a small accident the costs were very low. One of the test cases can be considered as a sever accident with long term effects. The numbers filled in the variables were all estimates because the cases were old and information about the variables was not yet collected. It might have been useful if the model could have been tested after one year of taking it to use. Then maximum amount of reliability could have been ensured. All of the variables in the model were thought to be good ones and realistic but without proper administrative support functions inside the organization collecting all the relevant data would be problematic. Unfortunately like in all other projects also this had deadlines so it was decided to test the model with already happened accidents, even if it meant less accurate results.

In the case information a small description of the accident will be provided with the lost time and estimate for costs. Time lost due to accident was considered time that was lost from all other daily work for all the personnel that are involved solving an accident case. The costs were rounded up to the next tenth. The testing with cases was made with respect to the privacy of the victims and other persons involved so all the names, titles, exact locations, dates have been left out from reporting. A scale of wages was used to represent the different levels of employees. The levels were divided into 4 levels of blue-collar and 6 levels of white-collar employees. The test information was presented in small tables in order to make things more clear for the reader (see tables 3,4,5,6 and 7).The tests results presented are done using the variables shown in the attachment 1. The test results also present the data as they were filled in the first place without corrections. This was to show also for the reader

the process of finding the errors in this model. Reading some of the test cases might also reveal for the reader some problems and contradictions in the basic logics of accident cost calculation models.

10.1. Test 1

TABLE 3. Test case 1

Employee level:	White-collar level 5
Time worked for the company:	3 years
Severity level:	Medium
Project type:	Environmental remediation
Description of the accident:	Using a spanner person was caught in a position where the spanner hit his nose and face.
Corrective action(s):	Safety talk
Cost variables used in calculation:	Securing the area and personnel, staff time to report and investigate accident, meetings to discuss incident, rescheduling the work activities and the salary costs of injured person while of work.
Total direct costs:	880 €
Time lost due to acccident:	72 hours

In this accident the person was unfastening bolts with a spanner in a bad position. The spanner slipped and he got hit by it in his nose. The health consequences of the accident were minor and the person was fully recovered. The severity level “medium” was given to this case because amount of sick leave was more than three days. Similar categorization is also used in other systems such as mentioned before in chapter 10. In this case the corrective safety action was safety talk for the victim. Although reminding of carefulness is important it was found out that it might have been useful to think deeper about the reason behind the accident. It could have been so that unfastening those bolts wasn´t possible in other position except the one that were the person accidently hit himself with a spanner. Then we could have found that

there would be need for some sort of customized spanner or some other way of doing the job more safely.

Most of the cost variables used in the calculation of the accident has little to explain. Maybe securing the area and personnel seems a bit excessive but that´s because several variables were bundled under it. Taking the victim to a hospital was one of the old variables bundled under the variable. This cost was considered to be very small and now thinking about it again it might be even a bit unnecessary. The total cost gotten by calculations was 880€ and it seems about right for a almost two week of absence from work. However is to be noted that if the job was done by reorganizing the work it could be said that there was no cost of what so ever. After all in Italy salary of the absent wage earner from work due to work related injury was paid by the INAIL. The cost is maybe more related to the lost productive value that the worker could have done for the company. The tutor person from Petroltecnica Riccardo Ponasso´s opinion was the it would be useful to make a distinction between these real cost (meaning the money out of the company) and the costs that were more related to the negative influence on the organizations daily activities (like more hassle due to less personnel working). Similar things can be said about the lost hours due to the accident.

10.2. Test 2

TABLE 4. Test case 2

Employee level:	Blue-collar level 3
Time worked for the company:	4 years
Severity level:	Medium
Project type:	Environmental remediation
Description of the accident:	Area cleaning using a high pressure cleaning device. Hot water with a high pressure broke the safety boots and burned the operator's feet.
Corrective action(s):	Safety talk, job safety analysis, update of safety instructions.
Cost variables used in calculation:	Securing the area and personnel, immediate staff downtime, staff time to report and investigate accident, meetings to discuss incident, rescheduling the work activities and the salary costs of injured person while of work.
Total direct costs:	990 €
Time lost due to accident:	90 hours

In the test case number 2 the victim was a field operator working in the environmental remediation unit. The person was washing the area using a high pressure cleaning device with hot water. For some reason the person hit his foot with the high pressure spout and the pressure cut his safety boot and burned the foot. The corrective actions were found out using accident investigation. As a result an update to the job safety instructions using high pressure cleaning device was done. The variables used to calculate the costs of this accident were the same as in the first case (see tables 3 and 4) with the exception of immediate staff downtime. This was due to the severity of the accident. All the people at the site were needed to secure the victim and take him to hospital. Total cost due to these costs was calculated using the model and the result was about 990€. The result seems realistic, but again we seem to face the same debate of the nature of these costs. Are these costs real money out of the company or are the costs more describing the lost production? Either way the main idea of gathering data of the costs of non-safety is still there. It is

possible to use the information when considering safety investments or the effect of these costs in the organizations operations. This is especially the case when using the accident reporting form created in this project, where you will also gather coherent information for decision making.

10.3. Test 3

TABLE 5. Test case 3

Employee level:	White-collar level 5
Time worked for the company:	3 years
Severity level:	Medium
Project type:	Environmental remediation
Description of the accident:	The operators shoe got caught in a little hole in the ground and a knee got twisted.
Corrective action(s):	Safety talk
Cost variables used in calculation:	Staff time to report and investigate accident, meetings to discuss incident and the salary costs of injured person while of work.
Total direct costs:	1770 €
Time lost due to accident:	163 hours

The third test case was quite basic case of small accident. A field geologist got her feet caught in a hole and twisted her knee in the progress. Obviously in this kind of accidents it is difficult to think any corrective actions and formal accident might feel useless, after all holes in the ground are quite impossible to prevent. Probably the accident was also discussed in a general safety meeting, so probably the costs of the meeting were evaluated a bit too high. This case just shows that in an average work accident most of the costs come from salary costs of injured person while of work. But again there is the fact that in Italy the salary costs of absent person due to injury are paid by the INAIL. The nature of these costs is already discussed in previous test chapters. The relevance of salary costs depends quite from the insurance system that the organization has to follow, in some cases the salary costs are really valid “money out” costs.

10.4. Test 4

TABLE 6. Test case 4

Employee level:	Blue-collar level 3
Time worked for the company:	4 years
Severity level:	Medium
Project type:	Remediation and removal of asbestos.
Description of the accident:	During dismantling a window a finger was cut badly.
Corrective action(s):	New safety procedure in building demolition.
Cost variables used in calculation:	Securing the area and personnel, staff time to report and investigate accident, meetings to discuss incident, rescheduling the work activities and the salary costs of injured person while of work.
Total direct costs:	1580 €
Time lost due to accident:	115 hours

The test case number 4 was quite similar to the case 3 for its nature. The injury itself was quite minor but resulted in an absence of almost three week out from work. The person injured in this case was a field operator in a demolition site dismantling a window and cutting his finger with a glass. The corrective action was a new safety procedure in building demolition. The variables used in the calculation are pretty much the same as in the previous cases. The results are also similar as in the previous test cases.

10.5. Test 5

TABLE 7. Test case 5

Employee level:	Blue-collar level 3
Time worked for the company:	6 months
Severity level:	Severe
Project type:	Environmental remediation
Description of the accident:	Burned by a flame caused by the vaporization of fluids containing hydrocarbons into gas.
Corrective action(s):	New procedure for operation of tank suction, new procedure for training employes and new tools for electrical ground system
Cost variables used in calculation:	Securing the area and personnel, staff time to report and investigate accident, meetings to discuss incident, rescheduling the work activities, time spent with local Health & Safety authority, the salary costs of injured person while of work, consulting fees and legal expenses.
Total direct costs:	96530 € (real value more closer to 45 000€)
Time lost due to accident:	3682 hours

The fifth test case was the most severe case that the model was tested. It also had the most variables used in the calculation of costs. The accident in self was very severe and made bad damage to the victim. The accident resulted in updating the process of tank cleaning and training of new employees. The victim of the accident was absent from work for almost two years and a new operator had to hired. It is to be noted that in using the costs calculation model it might make sense to put also these costs in the total costs. But it is not all so simple because the new worker is also doing productive work so it is not entirely just a cost. This mistake was done when filling out the form resulting to really high costs 96 520€. The real amount is probably about half of this when the costs of new persons salary are deducted. Even so the costs are about 45 000€ which already seems a bit more realistic. A great deal of administrative and investigative effort was put to in solving this terrible accident. It was also commented by one of the management of Petroltecnica that this kind of

individual tragedy causes a great deal of malaise and regret for a long period of time which affects all the people in the working environment. This being said it might be safety say that also the high monetary costs are quite realistic. After all this a kind of thing tends to lower the spirits of everyone and surely affects everyone's productivity. The costs were also increased a lot by the legal costs and consultant fees. A consultant was used to help in the investigation of this accident. There were also several meetings held for this accident, and a meeting with the local health and safety authorities. The accountability and credibility of results will be increased with proper administrative support functions, so that all the relevant data for the use of calculations will be gathered. The monetary and timely costs of occupational accident can be used for the decision making process of safety development and for reviewing the safety expenditure effectiveness.

11. IMPLEMENTATION OF THE RESEARCH

The goal to this bachelor´s thesis was set in a meeting in 7th of January 2010 at Petroltecnica Rimini office. Several options were considered but eventually it was decided that the work would be done about the costs of non-safety. This idea came originally from the company´s HSEQ manager Riccardo Ponasso. It was also decided that the work from home, and we would have a weekly meeting about the progress of this project in Petroltecnica office. The idea for this project was thought to be interesting also by the tutoring teacher Jouni Jurvelin who gave some material to begin the theoretical part of this Bachelor´s Thesis. The preliminary title for the thesis was “the costs model for non-safety”. The undersigned found this topic quite interesting and set out to work immediately. The sheer amount of information for the theoretical part was astonishing and the difficulty was to separate the essential information for this project.

The first part of this Bachelor´s project was to gather some theoretical background for the accident cost calculation model. It was also decided by the tutoring teacher and the client company´s representative that including a comparison of the Italian and Finnish systems for occupational health and safety would be interesting. Data collection about the work related accidents also related to different safety management systems and some effort was put to explain this connection see chapters 5 and 6. Second important part for theoretical background was to explain the use of information about the accident costs and to present some of the ways this work is being done in the field of OHS.

The sources and reference material was mainly gathered using the JAMKs JaNet-portal. The possibility to use the electronic books was crucial to the success of this thesis because it wasn´t so much possible to use the more traditional library services (the work was done in Italy). Luckily the JAMKs ebook collection was more than enough for the needs of theoretical information. Also a wide range of Internet

websites were used in writing this thesis. The writer tried to be as critical as possible in choosing the sources used.

The most difficult thing to find information about was the calculation models for accident costs. There isn´t too many of them (published at least) and some of them seemed quite outdated. The usability of these models for the client company Petroltecnica was also questionable. Reading about some of the published models the researcher found out that their approach was more appropriate for countries with less developed occupational health and safety systems. Maybe this was for the fact that they were many times done in universities of developing countries (see for example the models published in Journal of Safety Research - ECON proceedings 36). The most appropriate calculation model for Petroltecnica in my opinion was the one published by the UK Health and Safety Executive called *the Annual Accident Cost Calculator and Incident Cost Calculator*, which is possible to access through their website. Another great source by the same organization was a booklet called *The costs of accidents at work* (see References).

After the model for calculation was gathered the information and the variables were collected in electronic xml- and pdf-files. The researcher also decided to merge the accident reporting and investigation to the cost calculation. In this way a new way for collecting information about accident was created for the client company. It is to be seen whether it will be taken into use in the future. Electronic form was also good way to make the calculations easier. The whole thing of designing electronic forms and the software's used were totally new for the researcher so this work also needed a lot of studying. A great deal of help in completing this project successfully was gotten from Riccardo Ponasso who is the HSEQ manager in the client company Petroltecnica.

12. RESULTS OF THE RESEARCH

The results of Bachelors thesis project could be divided roughly into five categories: comparison of Finnish and Italian occupational health & safety systems, explaining the reasons behind accident cost calculation, information about the use of costs information, pointers on cost-benefit analysis, background for the model presented for the client and the electronic form for the company in two different file formats.

The comparison of Finnish and Italian occupational health and safety systems were not really big. Some differences were certainly found in law and in the way the compensations for the accident victim were paid. Both systems seemed to be very complicated and bureaucratic but this can probably be said about all legal systems and texts. Especially this applies when someone without education in legal issues tries to decipher them. These difficulties were the reason why the OHS system description part was quite light.

Information about the economic evaluation of safety performance and different incentives the organizations have for gathering data about accident costs was given for the client company. Most of the thing presented in chapters 4 and 5 were probably known for the assigning organization of this project, but hopefully the chapters presented also some new viewpoints for whoever is interested in this topic. The point that was clearer after studying the theoretical background was that an accident truly affects a great deal of different parties from the victim even all the way to the society. It is in everyone´s interest that the continuous work towards safer workplaces is done by the responsible organizations and also in a governmental level. Some insights were presented in how to use the information about the accident costs for example: when deciding on where to do investments on safety. The Bachelor´s thesis could have discussed more also about the administrative support functions needed for the collection of needed facts from accidents.

Some background information for the calculation model chosen is also presented in this project. Also pointers on the use of cost-benefit analysis were given to clarify the usefulness of the created model. Idea of merging the accident reporting with the costs calculation might prove to be useful for the client company if the reporting method is to be taken use. However this will also require some administrative organizing to be fully effective system of accident reporting and calculation for costs. The work was culminated in the electronic reporting forms that are also discussed earlier in chapter 9 and 10. With minor adjustments a similar calculation method could be used also in other companies or organizations. Much better and efficient results in the gathering of cost calculation data could have been gained if the company would have had software able to manage and gather electronic documents. With such software it would have been possible to make a simple system where gathering and extracting information about the costs would have been easier.

13. DISCUSSION

Comparing the goals and the results of this project I´d say that it was completed quite successfully. We managed to find quite an appropriate model for calculating the accident costs, but we also prepared a systematic way of accident data collection for the use of the client company Petroltecnica. In the beginning of this project the about the amount of things written about this topic related to safety was bewildering. It seemed difficult to decide which were the most important things to concentrate on.

The greatest difficulties were probably in the comparison of Finnish and Italian legal systems. Problem was the little previous experience with occupational health and safety laws. This might have resulted to a quite light presentation of these issues. The whole legal field was too complicated to be discussed much in this thesis. The really practical part in this project was to gather the different cost calculation variables into a single form. This was relatively easy because we found a good list of these from the studies made by the UK Health & Safety Executive. A great deal of thinking was put into checking these variables and customizing them for the usage of Petroltecnica. At this time also other published models were considered, also some of the computer programs made for accident cost calculation. Unfortunately it wasn´t possible to test these programs because the owners of these programs didn´t want to give any test versions. Neither the correspondence was actually answered, which is a shame really. The problem that we faced in the end of this project was the testing phase. There wasn´t really any ready models for comparing the results gained using this model. This is not to say that there isn´t other models, just that they are published in a format that requires a great deal of customizing in order to directly use them.

A thing that was learned during this project was that it is very difficult to get exact numerical values for the costs of accidents. This is because not only the costs are divided into direct and indirect, but also to *“real money out of the company costs”* and to *“organizational costs”* which meant the lost productive value due to accident. In the case of the client company these two types of costs became obvious when we tried to input monetary values into one our forms. There was some debate on whether for example the salary costs of the accidents victim were to be counted as

costs, after all the company has to pay salary anyway. Maybe some of this confusion was due to the lack of exact information on the actual costs when some calculation variables were concerned. According to Ponasso this would be solved by creating administrative guidelines in what information to collect when an accident happens, this would eliminate the errors coming from evaluation and guessing. This way probably almost all of the variables presented in the form would be relevant. This is just an assumption however and not tested. This was problem was relevant just in some of the variables seen in the cost calculation form, but anyway it might be interesting research topic for some future studies in the field of accident costs calculation.

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Informazioni amministrative

DATA DELL´INFORTUNIO: ORA:

PROGRESSIONE DEL REPORT

DATA DEL PRIMO REPORT:

Inizio ☐

SETTORE:

Fine ☐

LUOGO DELL´INFORTUNIO (CITTÁ/REGIONE/NAZIONE):

Commenti:

REPORT REDATTO DA:

RESPONSABILE DELL´AREA:

DITTA APPALTATRICE: TEL:

SUBAPPALTATORE: TEL:

PERSONALE COINVOLTO NELL´INFORTUNIO

Impiegato della Petroltecnica ☐

Appaltatore

Operaio Select

Subappaltatore

Impiegato Select

Parti terze

REPORT DELL´INFORTUNIO

Attivitá in corso:

Descrizione dell´infortunio: (chi-cosa-quando-dove)

Tipo di infortunio / Ferita

Parti del corpo | Parti del corpo | Parti del corpo | Parti del corpo

Livello di gravitá

Tempo perso (Illeso) ☐ Ferita ☐ Infortunio ☐ Morte ☐

Nessun trattamento ☐ Capacitá lavorative limitate temporanee ☐

Cure mediche ☐ Capacitá lavorative limitate permanenti ☐

Pronto soccorso ☐

PERSONALE COINVOLTO DIRETTAMENTE NELL´INFORTUNIO

Infortunati	Mansione	Anni di lavore nell azienda	Anni di lavoro nella posizione lavorativa odierna

TESTIMONI DELL´INFORTUNIO:

NOME: TEL. CELLULARE:

INDIRIZZO: CITTÁ/NAZIONE:

Indagine sull´infortunio

OBIETTIVI

1. Identificare le cause dell´incidente e i problemi all´origine di esse.
2. Trovare le possibili soluzioni inerenti alla sicurezza sul lavoro.

Inizio dell´indagine: Fine dell´indagine:

Gruppo che ha eseguito l´indagine

Nome	Mansione	Contatti

COMMENTI

Cause/ fattori aggiuntivi. Perché é successo? Deve esserci almeno un fattore causa.

FATTORI PERSONALI:	FATTORI INERENTI AL LAVORO:	FATTORI ESTERNI:
(1) Preparazione insufficente o mancanza di conoscenze (2) Non osservanza delle procedure/comportamenti accettabili poiché ció richiede piú tempo/impegno ("Scorciatoia") (3) Procedure "scorciatoia" o comportamenti accettabili sono incoraggiati o tollerati (4) Non osservanza delle procedure/comportamenti tollerati	(5) Mancanza o ineduaguezza della/e procedura/e (6) Errata informazione inerente alle aspettative sull´osservanza delle procedure e sui comportamenti tollerati (7) Strumenti di lavoro/equipaggiamento inadeguato	(8) Impossibilitá di prevenire l´infortunio

Rootcauses

1. 3.

2. 4.

5.

La/e soluzione/i devono corrispondere alle "root causes"	Responsabilitá personale	Data stimata per la messa in sicurezza	Data di attuazione	Completato

Raccolta di prove o allegati:

Calcolo stimato per i costi non coperti dall´assicurazione

Costi per il tempo perso

Infortunio (azioni immediate)	Tempo (h)	Costo (€)	Costo totale
Messa in sicurezza del personale e dell´area			
Downtime immediato del personale			
Indagine sull´infortuio			
Tempo impiegato dal personale per il report e per l´indagine sull´infortunio			
Incontri per discutere dell´infortunio ecc.			
Raccolta delle evidenze			
Tempo speso con il Responsabile Servizio Tutela della Salute e Sicurezza nei luoghi di lavoro			
Quota per la consulenza d´indagine			
Ripresa del lavoro			
Riorganizzazione delle attivitá lavorative			
Ripresa del lavoro/ della produzione			
Pulizia del sito			
Rilavorazione del prodotto			
Riparazione dei danni ai macchinari o alle attrezzature			
Business costs			
Costo del salario dell´infortunato durante il tempo di assenza dal lavoro			
Costi di assunzione del lavoratore sostituto			
Formazione del nuovo lavoratore assunto			

Costo del salario del lavoratore assunto			
Ore extra per riavviare la produzione			

Totale di tempo e soldi spesi		

Ulteriori costi stimati

	Costo totale
Sopperimento di risorse alternative ai clienti	
Affitto di strumenti, attrezzature, impianti, servizi ecc.	
Ritardi	
Clausola penale da contratto	
Ordini cancellati/persi	
Perdita dei profitti dovuti all´interruzione del lavoro	
Risarcimento pagamenti	
Onorario per l´avvocato e spese legali	
Tempo speso dal personale per risolvere le questioni legali	
Multe e costi dovuti alle procedure penali	

Totale dei costi ulteriori stimati	

Totale dei costi non coperti dall´assicurazione	