Semi- quantitative valuation of risk treatment

- A model for premium distribution based on fire loss prevention

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Abstract
The objective of this master's thesis has been to develop a model for valuation and comparison between SCA plants with reference to fire loss prevention work. The aim of this report has been fulfilled by analysing results from literature studies, interviews and questionnaires answered by persons experienced within fire loss prevention work and paper industry. The report resulted in a Loss Prevention Point model able to make valuation and comparison between SCA plants. The model is able to provide risk managers with information making it possible to distribute insurance premium.

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Summary

The objective of this master's thesis has been to develop a user-friendly model for valuation and comparison between Svenska Cellulosa Aktiebolaget, SCA plants, with reference to fire loss prevention work. SCA underlying objective with this master's thesis is to use the model in their premium distribution within Europe.

SCA is an international paper and forest products company that produce absorbent hygiene products, packing solutions and public paper. SCA runs a captive insurance company, SCA Insurance company, SCAF[1], which determines an annual total insurance premium that must be distributed among the plants within SCA. Within SCA the most common loss is derived from fire and consequently the risk treatment is focused on fire loss prevention.

To fulfil the objective the following questions has been identified and answered in the report:

- How to identify factors effecting the valuation of fire loss prevention, and how to make a selection between them?
- How could these factors be classified and quantified?
- How are the relations between the factors, are they of different importance to the total valuation?
- How to obtain the information about the factors in an objective way?
- How to contribute factors into one expression of risk treatment?

In consideration of the objective, the used method contains the following fundamental steps. Apparently, the used method has similarities with Multiple Attribute Decision Making, MADM method.

Identification
Factors reflecting the fire loss prevention work were identified and a reasonable number of valuation factors were selected. The identification and selection are based on a literature study, interviews and a group meeting with SCA Risk Management department in Stockholm.

Classification
The valuation factors were classified in order to clarify and facilitate the communication and understanding of the result from the model. In order to facilitate the risk communication, the factors were divided by the moment of the implementation, before or after the risk become a problem. The valuation factors are consequently classified as Pre-risk options or Post-risk options.

Weighting
The valuation factors were assigned weights according to their importance to fire loss prevention. The weighting were derived from a questionnaire answered by persons experienced within fire loss prevention work and paper industry.

Valuation and quantification
A reasonable number of valuation levels were established and quantified. An example of how to make the model more objective is given, as criteria example related to each valuation level.

Final valuation
An appropriate method for combine and sum up the factors individual weight and value was selected. The received scoring intended to reflect each plant's risk treatment.

[1] Svenska Cellulosa Aktiebolaget Försäkringsbolag

The result of the identification, classification and weighting are as follow.

Factors classified as Post-risk option	**Weighting (order of rank)**	**Factors classified as Pre-risk option**	**Weighting (order of rank)**
Automatic extinguishing systems	0,115 (1)	Risk Management	0,105 (3)
Fire separation	0,107 (2)	Hot work permits	0,104 (4)
Fire detection and alarm	0,101 (6)	Self inspections and maintenance of existing plant facilities	0,103 (5)
Manual fire fighting equipment	0,094 (8)	Impairment procedures	0,096 (7)
Public and in-house fire brigade	0,093 (9)	Security and access control	0,080 (10)

Each factor was assigned four valuation levels, Poor, Fair, Good and Very good. Each valuation level was quantified with the number 1-4, where 4 represent Very good. In order to make the valuation more objective a criteria guideline is developed based on the PDCA-cycle[1]. The respective valuation level is assigned examples of criteria to ease the process. The criteria examples are based on the criteria guideline derived from the SCA Fire Loss Prevention Guideline, FLP and adjusted to each valuation factor.

The Simple Additive Weighting Method, SAW method is used in order to combine and sum the factors individual weight and value. The SAW method is the best-known and most widely used MADM method, and obtains scores by adding the contributions from each factor.

The master's thesis resulted in a Loss Prevention Point model, LPP model that gives results varying from 1 to 4, where 4 is the maximal scoring. A sensitivity analysis shows that the weighting favour post-risk options with a slightly difference. A case study shows that the model intends to overestimate plants irrespectively of the quality of fire loss prevention. Consequently the model gives no room and possibility to reward further improvements. The scoring does nevertheless give a comfortably differentiation between the plants, even though the LPP model must be used with rationality and common sense.

From the results of the LPP-model the most important conclusions that have been made are as follow.

- The model is able to provide SCA Risk managers with information, making it possible to distribute the premium with reference to fire loss prevention.
- The usage of the LPP-model is limited to SCA plants in Europe and must be revised continuously. It is particularly important to continuously modify the valuation criteria, which always must be updated and adjusted to present preferences in order to validate the reliability of the model.
- It is possible to add or delete valuation factors to the LPP-model, on conditions that the steps in the method are repeated. As soon as the valuation factors changes, the weighting must be modified.
- The valuation assessors must be versed in fire loss prevention work and fully informed about the present preferences and valuation criteria. The valuation criteria could be modified, revised and increased to raise the objectivity in the model.
- The LPP-model will give the user a relative value of risk treatment, not an absolute value. Furthermore, the model is deliberately limited to only consider risk treatment options related to fire or explosion.
- The used method could with adjustments be appropriate to other companies or interested parties, on conditions that the method is adjusted to their preferences and conditions.

[1] A model for accomplishes continuous improvements, developed by W.E Deming.

Sammanfattning (Summary in Swedish)

Syftet med detta examensarbete har varit att ta fram en användarvänlig modell för att uppskatta och jämföra anläggningar ägda av Svenska Cellulosa Aktiebolaget, SCA, med avseende på brandskadeförebyggande arbete. SCA: s har i sin tur för avsikt att använda modellen som ett underlag för premiesättning av anläggningar.

SCA är ett globalt konsument- och pappersföretag som bland annat producerar hygienprodukter, mjukpapper, förpackningslösningar och tryckpapper. SCA har ett internt försäkringsbolag, Svenska Cellulosa Aktiebolaget Försäkringsbolag SCAF, som varje år beslutar en årlig premie som skall fördelas mellan SCA: s anläggningar. Inom SCA kan den mest förekommande skadekostnaden härröras från brand varför SCA: s ”risk treatment” är fokuserad på brandskadeförebyggande arbete.

Följande frågeställningar besvaras i rapporten:

- Hur kan de faktorer som påverkar uppskattningen av brandskadeförebyggande arbete identifieras, och hur kan ett urval av dessa göras?
- Hur kan dessa faktorer klassificeras och kvantifieras?
- Hur ser relationen ut mellan faktorerna, är de av olika betydelse för den slutliga uppskattningen?
- Hur kan information om faktorerna insamlas på ett objektivt sätt?
- Hur kan faktorerna kombineras till en uppskattning av risk treatment?

Metoden som används i denna rapport har vissa likheter med MADM-metoden. De fundamentala stegen i metoden som används i denna rapport utgörs av:

Identifiering
Faktorer som utgör det brandskadeförebyggande arbetet inom SCA identifierades och ett passande antal värderingsfaktorer valdes ut. Identifieringen och urvalet baserades på litteraturstudier, intervjuer och ett gruppmöte med SCA Risk Management avdelning i Stockholm.

Klassifikation
Värderingsfaktorerna klassificerades med syfte att förtydliga och underlätta kommunikationen och förståelsen av modellens resultat. Faktorerna klassificerades således med avseende på när de skadeförebyggande åtgärderna implementerats, före eller efter att risken orsakat problem. Faktorerna delades således upp i ”Pre-risk options” och ”Post-risk options”.

Viktning
Värderingsfaktorerna blev tilldelade vikter med hänsyn till deras betydelse för SCA: s skadeförebyggande arbete. Viktningen har sitt ursprung i den enkätundersökning som genomförts i detta examensarbete. Enkäterna besvarades av personer med erfarenhet av skadeförebyggande arbete inom pappers och skogsindustrin.

Uppskattning och kvantifiering
Ett rimligt antal uppskattningsnivåer upprättades och kvantifierades. Till uppskattningsnivåerna upprättades en kriterieguide med syfte att göra modellen mer objektiv. I rapporten gavs även exempel på kriterier för de ingående värderingsfaktorerna.

Slutlig uppskattning
En lämplig metod valdes ut för summering av varje faktors individuella vikt och värde. Den slutliga summeringen syftade till att reflektera varje anläggnings individuella ”risk treatment”.

Resultatet av identifieringen, klassificeringen och viktningen följer enligt nedan.

Faktorer klassade som Post-risk option	**Vikt (ranking)**	**Faktorer klassade som Pre-risk option**	**Vikt (ranking)**
Automatic extinguishing systems	0,115 (1)	Risk Management	0,105 (3)
Fire separation	0,107 (2)	Hot work permits	0,104 (4)
Fire detection and alarm	0,101 (6)	Self inspections and maintenance of existing plant facilities	0,103 (5)
Manual fire fighting equipment	0,094 (8)	Impairment procedures	0,096 (7)
Public and in-house fire brigade	0,093 (9)	Security and access control	0,080 (10)

Varje faktor tilldelades fyra uppskattningsnivåer, Poor, Fair, Good och Very Good. Varje nivå kvantifierades från 1 till 4, där 4 representerar Very Good. Med syfte att göra uppskattningen mer objektiv upprättades en kriterieguide som är baserad på PDCA-cykeln[1]. Varje faktor har tilldelats exempel på kriterier med syfte att öka objektiviteten i uppskattningen. De kriterier som tilldelats faktorernas uppskattningsnivåer är baserade på kriterieguiden, härrör från SCA Fire Loss Prevention Guideline, FLP och är anpassade efter varje faktor.

The Simple Additive Weighting Method, SAW-metoden har använts med syfte att kombinera och summera faktorernas individuella uppskattning och vikt. SAW-metoden är den mest välkända och mest använda MADM-metoden. SAW-metoden frambringar poäng för varje anläggning genom att addera bidragen från varje ingående faktor.

Examensarbetet resulterade i en Loss Prevention Point modell, LPP modell som ger ett resultat varierande från 1 till 4, där 4 är den maximala poängen. En känslighetsanalys visar på att den framtagna viktningen gynnar ”post-risk options” en aning. En ”case study” visar på att den framtagna modellen tenderar att överskatta anläggningarnas ”risk treatment”, oavsett kvalitet på det brandskadeförebyggande arbetet. Detta medför att modellen inte ger utrymme att premiera ytterligare förbättringar. Resultatet från modellen ger dock tillräcklig information för att kunna särskilja anläggningarna åt. Modellen måste dock användas med eftertanke och logiskt tänkande.

Utifrån de resultat som erhållits har ett antal slutsatser dragits, nedan redovisas de mest betydelsefulla.

- Modellen kan tillhandahålla SCA Risk Managers med information som gör det möjligt att fördela premier med avseende på brandskadeförebyggande arbete
- LPP-modellen är begränsad till Europeiska anläggningar inom SCA och måste regelbundet revideras. Det är särskilt viktigt att uppdatera värderingskriterierna, vilka alltid måste spegla de gällande preferenserna för att upprätthålla validiteten och tillförlitligheten i modellen.
- Det är möjligt att lägga till eller att ta bort värderingsfaktorer i LPP-modellen, förutsatt att samtliga steg i den använda metoden repeteras. Så snart värderingsfaktorerna ändras måste viktningen modifieras.
- Personerna som uppskattar faktorerna måste ha kunskap inom skadeförebyggande arbete och vara väl informerade och insatta i gällande preferenser och aktuella värderingskriterier. Värderingskriterierna kan uppdateras, revideras och utökas för att på så sätt öka objektiviteten i modellen.
- LPP-modellen ger en relativ uppskattning av ”risk treatment options”, ej ett absolut värde.
- Metoden kan användas av andra företag och intressenter förutsatt att den anpassas efter det enskilda företagets/intressentens egna preferenser och förutsättningar.

[1] En modell för att uppnå kontinuerlig förbättring, utvecklad av W.E Deming.

Vocabulary – Glossary

Attributes	See Valuation factors
Evaluate	Compare a estimated level against a pre-established criteria
Fire loss prevention	An proactive intention to prevent larger losses, caused by fire, to occur
Fire prevention	An proactive intention to prevent fires to occur
Loss prevention	An proactive intention to prevent larger losses to occur
Loss Prevention Point (LPP) model	The model developed in this master's thesis. A model for quantitative valuation and comparison between plants, with reference to fire loss prevention work
Multiple Attribute Decision Making (MADM) method	Method for making preference decisions (e.g., evaluation, prioritisation, selection) over the available alternatives that are characterized by multiple, usually conflicting attributes
PDCA-model	A model for accomplishes continuous improvements, developed by W.E Deming
Pre-risk option	A risk treatment option, implemented before the risk becomes a problem, in a preventative fashion
Premium distribution	The act of distributing the payment for insurance between the policyholders
Post-risk option	A risk treatment option, implemented after the risk becomes a problem, in order to try and contain the impact that the risk may have
Risk	Combination of the probability of an event and its consequences
Risk Treatment	Process of selection and implementation of measures to modify risk
Risk Management	Coordinated activities to direct and control an organization with regard to risk
Simple Additive Weighting (SAW) method	The SAW method is the best-known and most widely used MADM method and obtains scores by adding the contributions from each factor
Survey reports	Inspection report underlying the premium distribution
Treat risk	See risk treatment
Valuation	Estimation
Valuation criteria	The valuation criteria aim to make sure that the valuation will be based on the same underlying reasons and reduce the divergence in the results
Valuation factor	Factors effecting the valuation of fire loss prevention. The factors are valuable and appropriate for premium distribution
Valuation maker	The person valuing the valuation factors
Weighting	Quantification of the factors importance to the fire loss prevention
Weighted Product Method (WPM) method	An MADM method, obtaining scores by multiplying contributions from each attribute

Acronym

AIRMIC	The Association of Insurance and Risk Managers
ALARM	The National Forum for Risk Management in the Public Sector
AS/NZS	Australian/New Zealand Standard
COSO	The Committee of sponsoring Organizations of the Treadway Commission
EML	Estimated Maximum Loss
IRM	The Institute of Risk Management
ISO	International Organization for Standardization
LPP	Loss Prevention Point
SCA	Svenska Cellulosa Aktiebolaget
SCAF	SCA Insurance company (SCA Försäkringsbolag)
SRM	SCA Survey report manual
FLP	SCA Fire Loss Prevention Guidelines
MADM	Multiple Attribute Decision Making
RTO	Risk Treatment Option
WPM	Weighted Product Method

Table of contents

1 Introduction and background

Every day, insurance companies all over the world make premium distributions. Among other factors these premium distributions are based on the client's risks and Risk Management. The clients, who are aware of, handle and minimize their risks, pay a lower premium than the clients who are unaware of the risks they possibly could be exposed to. How the insurance companies make this distribution depends on several factors and varies between the companies. There is no commonly used model for premium distribution at present. Consequently, insurance companies decide for themselves on which factors their premium distribution should be based. The variation is boundless.

Svenska Cellulosa Aktiebolaget, SCA has developed the fundamental idea to this master's thesis.

1.1 SCA

SCA is an international paper and forest products company that produce absorbent hygiene products, packing solutions and public papers. SCA was formed and incorporated 1929 as a holding company for some ten forest-industry companies in northern Sweden. 1954 the former independent units merged with the parent company, SCA. SCA is headquartered in Stockholm and has about 50,000 employees in 40 countries.

SCA's operations could be organised into three business areas:

Hygiene Products with production of tissue products, baby diapers, feminine hygiene products and incontinence products.

Packaging with production of corrugated board, containerboard and moulded pulp.

Forest Products, which produces printing paper, publication paper, newsprint, pulp, solid wood products, timber and forest-based fuel.

1.1.1 SCA Insurance Company

SCA runs a captive insurance company, SCA Insurance company, SCAF. The insurance company determines an annual total insurance premium that must be distributed among the plants within SCA. Primarily the distribution depends on the size of the plant's insurance amounts and secondary based on how well the plants treat their risks. Within SCA risk treatment is performed through loss prevention work. Within SCA the most common loss is derived from fire and consequently the risk treatment is focused on fire loss prevention. SCAF's premiums are determined "top down" based on loss prevention qualities. The reason of this is that SCA want to stimulate improvement in loss prevention work and not punish plants with a bad record. An important and recurrent question is, how SCAF should do the premium distribution in an appropriate way. How are they supposed to valuate the quality of the loss prevention work? The endless variation of Risk valuation makers makes it difficult to compare the loss prevention work. At present there is great subjectivity in this valuation. This master's thesis intends to give a proposal of how the, at present subjective, determination could be carried out in a more objective way.

1.2 Objective

The objective of this master's thesis is to develop a model for quantitative valuation and comparison between SCA plants with reference to fire loss prevention work. To fulfil this objective the following questions have been identified and will be answered in the report:

- How to identify factors effecting the valuation of fire loss prevention and how to make a selection between them?
- How could these factors be classified and quantified?
- What are the relations between the factors, are they of different importance to the total valuation?
- How to obtain the information about the factors in an objective way?
- How to contribute factors into one quantitative expression?

The model aims to be user-friendly, adjusted to plants within SCA and with concatenation to SCA Fire Loss Prevention Recommendation, FLP (2005)[4]. Furthermore the model aims to be reasonable complete, objective and at the same time practically usable and obvious.

[4] Guideline with reference to fire loss prevention within SCA.

2 Method and scope

This report has, when it is possible, used the terminology for Risk Management set out by the International Organization for Standardization, ISO (2002).

2.1 Approach

The master's thesis started with a research for already existing potential methods. When a method for the specific demands was not to be found, a literature study followed. The literature study aimed to procure enough knowledge to develop a method for valuation of the fire loss prevention work within SCA. With the knowledge received from the literature study an approach was carried out and an outline were performed, shown to the left in figure 2.1. The outline of the approach made it clear that there is a great similitude between the approach and the Multiple Attribute Decision Making, MADM methods. The MADM methods fundamental steps are shown to the right in the same figure as the approach.

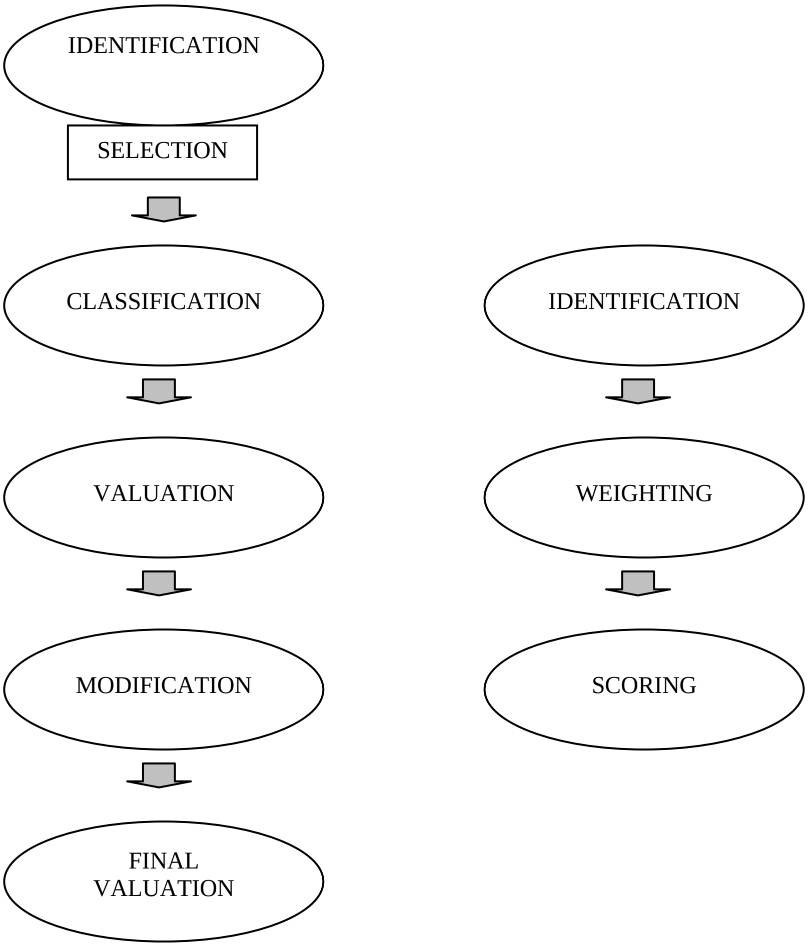

Figure 2.1 Left: Approach. Right: MADM-method.

According to Yoon & Hwang (1995) it is important to keep the following questions in mind, when selecting a method for decision-making:

- Is the method appropriate to the problem, the people who will use it, and the institutional settings in which it will be implemented?
- Is the method easy to use?
- Is the method expected to be valid, i.e. reflecting the purpose of the valuation?

There exists several MADM methods, and with previous questions in mind only two of them are appropriate to valuation of fire loss prevention within SCA, see chapter 3.4.3. To facilitate the usage and clarify the affect of the valuation model existing, SCA documents and terminology were used as much as possible.

To meet the demands from SCA, a combination between the MADM methods and the approach was performed and used in this master's thesis. A secondary objective with the modified method was to make it possible to use SCA's existing terminology, policies and documents.

2.2 Method

2.2.1 Identification

In order to save time and work the potential factors are identified through already existing SCA documents. The identification of the valuation factors is made with the assumption that SCA already identified the factors most important for them.

To make the model practically usable a reasonable number of valuation factors are selected. The selection intends to make sure the selected valuation factors are reflecting the fire loss prevention work within SCA. According to the extent of the model application the selection is performed through interviews and group meeting with SCA Group Risk Manager and Risk Manager Loss Prevention. The interviews intend to give underlying information about the factors importance and a proposal of which factors to drop or add. The group meeting aim to make sure the selected valuation factors representing the quality of each plant's fire loss prevention work. If the group meeting involve any disagreements about "select or drop the factor" concerned factor always will be selected.

2.2.2 Classification

The classification is made in order to clarify and facilitate the communication and understanding of the result from the model.

2.2.3 Weighting

To identify if the valuation factors are of different importance to the fire loss prevention a questionnaire will be performed and sent out. The questionnaire will result in individual weights assigned each valuation factor. The weighting aims to represent the factors importance to fire loss prevention.

2.2.4 Valuation and quantification

To make the valuation possible, a reasonable number of valuation levels are established. The valuation levels are assigned criteria examples related and adjusted to each valuation factor. To achieve correct valuation the related criteria must be fulfilled.

2.2.5 Final valuation

The objective with the final valuation is to quantify the quality of the fire loss prevention work and calculate each plants final score in a comparative matter. The final valuation consists of two steps, first to combine each factors weight and valuation and then sum all valuation factors to get the plant's final score. This calculation is done in accordance to an appropriate MADM-method.

2.3 Limitations

The method is adjusted to SCA plants and interests. Received model is based on SCA documents and consequently limited to plants within SCA. The model is deliberately limited to only consider risk treatment options related to fire or explosion. The model will thereby not include strictly economical and financially risks, mechanical damage or environmental risks.

The model in this report is restricted to SCA plants in Europe and will give the user a relative value of risk treatment, not an absolute value.

3 Theory

3.1 Risk

Risk is a part of everyday life and appears in many forms. There are economic risks, physical risks, social risks etc. Each individual defines risk widely different but one common concept in almost all definitions is the uncertainty of the outcome. Some describe risk as having only unpleasant consequences, while others are neutral. What one person finds harmful, another may not. That is why there are many definitions of risk in use and no one generally accepted. This report will use the definition according to ISO (2002), expressed as:

Risk

Combination of the probability of an event and its consequences.

This definition is simple and gives risk possibility to be concerned with both positive and negative consequences. In this report mostly the negative consequences will attract attention.

3.2 Risk Management

Risk Management is not a new concept; it has been performed everyday and everywhere from the early beginnings of humanity. From the beginning Risk Management was about protecting the human in the village from animals. Nowadays Risk Management aims to reduce costs and the company's reputation, etc. The risks vary with time; development and new techniques always involve new risks. As with the definition of risk, there are many definitions of Risk Management in use. This report will use the definition according to ISO (2002), expressed as:

Risk Management

Coordinated activities to direct and control an organization with regard to risk.

Risk Management includes a varying number of elements. The most fundamental elements are *identification*, *analysis*, *evaluation* and *treatment*. These elements occur, one way or the other, in every Risk Management process. According to ISO (2002) Risk Management generally includes Risk Assessment, risk treatment, Risk Acceptance and Risk Communication. This report prefers to use an increased and more detailed interpretation, comprised by seven main elements (Australian/New Zealand Standard [AS/NZS], 2004).

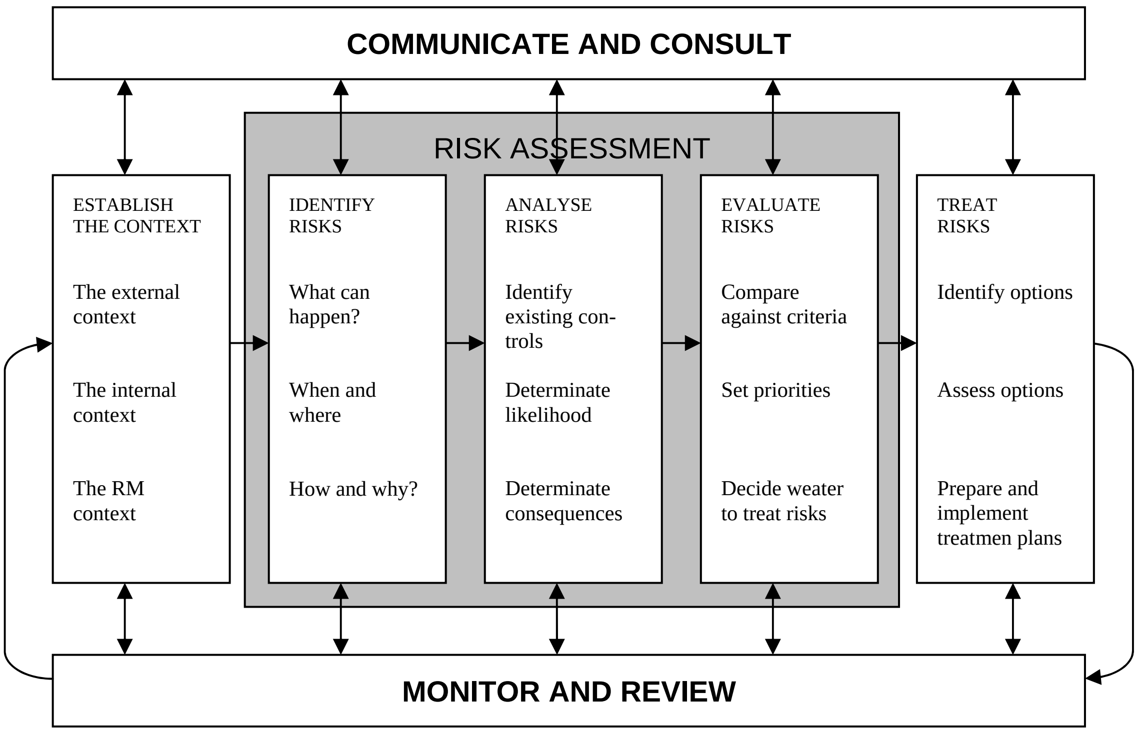

Figure 3.1 Risk Management process.

The main elements are, as shown in figure 3.1, the following:

Communicate and consult
Communicate and consult with internal and external stakeholders at each stage of the Risk Management process and concerning the process as a whole. It is important to develop an effective communication plan for both internal and external stakeholders. The communication plan should ensure that those responsible for implementing Risk Management and those with increased interest understand the basis on which decisions are made and why particular actions are required.

Establish the context
Establish and define the external and internal Risk Management context in which the process will take place; develop a Risk Management strategy. It is important to define the structure of the Risk Analysis and establish criteria for which risks will be evaluated against. These considerations should set the scope for the rest of the Risk Management process and include a definition of the basic parameters within which risks must be managed.

Identify risks
Identify where, when, why and how adverse events could impact the achievement of the objectives. The identification of risk sources and impacts will be the basis for the determination of the risk treatment strategy. It is important that the identification process is comprehensive, well structured and systematic. The identification should include risks whether or not they are under control within the organization.

Analyse risks
Identify existing risk treatment options and assess their effectiveness. Determine likelihood and consequences and hence the level of risk, for each identified risk. It is important that the analysis provides an input to decisions on whether risks need to be treated. The analysis should also clarify the most appropriate and cost-effective risk treatment strategies. The analysis should furthermore evaluate existing risk treatment options.

Evaluate risks
Compare estimated level of risk against the pre-established criteria and determine whether the risks are acceptable or unacceptable. The evaluation often considers the balance between benefits and adverse outcomes. An acceptable risk should be monitored and regularly reviewed to ensure it remains acceptable. An unacceptable risk should be treated. The evaluation, of the unacceptable risks, enables decisions to be made about risk treatment s and priorities.

Treat risks
Give priority to the unacceptable risks and develop a proper treatment strategy. Determine appropriate treatment options for the risks according to selected treatment strategy. The selection of preferred treatment options should take into account factors such as costs and effectiveness. It is important that the costs of the implementation of each treatment option matches to the benefits derived from it.

Monitor and review
In order to achieve continuous improvement it is necessary to monitor and review the effectiveness of all steps of the Risk Management process. It is important that the management plan remains relevant and up to date.

The AS/NZS Risk Management process follows W.E Deming’s PDCA-model. The PDCA-model is defined for quality management systems and illustrates one way of attain continuous improvements. The PDCA-model is called the PDCA-cycle or Deming’s-circle and is defined with four phases (Akselsson, 2004):

Plan What is the present state?
What is the objective?
How to achieve the objective?

Do Allocate resources.
Inform and educate.
Carry through.

Check What is the quality of the outcome?
Are the changes achieving the desired results or not?

Act Evaluate and assess.
Review and correct.
Process standardisation.

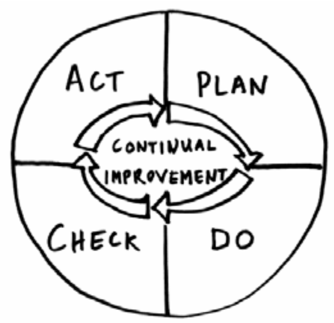

Figure 3.2 The PDCA-cycle.

The PDCA-cycle is a continuous cycle that means you can start the work wherever you like. To assure continuous improvement the most essential is to repeat the cycle continuously within the entire organization (Det Norske Veritas & Vestlandsforskning, 2002). The PDCA-cycle is possible to use in every existing process in order to achieve continuous improvement.

3.2.1 Good Risk Management

There are several important characteristics indicating good Risk Management. Some of them are stated as follows.

It is important that the approach to Risk Management is *adopted at the highest level* of the organisation and *implemented at all functional levels* of the organisation despite the differences in the responsibility activities and nature of the risk at each level (Shortreed, Craig & McColl S., August, 2000).

The process should be *flexible* and *iterative* (Shortreed, J.H., Craig L. & McColl S., August, 2000).

Risk Management should be *a continuous and developing process* (The Association of Insurance and Risk Managers [AIRMIC], The National Forum for Risk Management in the Public Sector [ALARM] & The Institute of Risk Management [IRM], 2002).

The Risk Management must be *integrated into the culture of the organization* with an effective policy and programme led by the most senior management. It must *translate the strategy into tactical and operational objectives*, assigning responsibility throughout the organization with *each manager and employee responsible* for the management of risk as a part of their job description (AIRMIC, ALARM & IRM, 2002).

Effective Risk Management requires a *reporting and review structure* to ensure that risks are effectively identified and assessed and that appropriate controls and responses are in place (AIRMIC, ALARM & IRM, 2002).

Regular audits of policy and standards compliance should be carried out and standards performance reviewed to *identify opportunities for improvement*. It should be remembered that organizations are dynamic and *operates in dynamic environments* (AIRMIC, ALARM & IRM, 2002).

A good Risk Management environment is one that supports responsible Risk Management, where Risk Management is *built into existing organizational governance structures*, and planning and operational processes (Treasury Board of Canada Secretariat, March, 2003).

Risk Management is *a dynamic process*, not static. It changes based on events that occur internally and externally. To *learn from our mistakes and those of others* could prevent losses such as lives, injuries and damage (Loflin & Kipp, 1997).

3.3 Risk Treatment

Risk treatment has many names for example, Hazard Management, Risk Management, Risk Control, Treat Risks, Risk Control techniques etc. Within this report the expression risk treatment will be used and defined in accordance with ISO (2002):

Risk Treatment

Process of selection and implementation of measures to modify risk.

Risk treatment is the process of selection and implementation, not only the measures themselves. Risk treatment often includes these steps; identify options, assess options, prepare and implement treatment plans and analyse and evaluate residual risk (AS/NZS, 2004). This report will concentrate on the implementation of already identified and selected treatment options.

RISK TREATMENT
Identify options
Assess options
Prepare and implement treatment plans

Table 3.1 Risk Treatment

3.3.1 Risk Treatment options

Risk treatment options, RTO can be divided into several different groups. Fore example; Risk Avoidance, Risk Reduction, Risk Transferring/Sharing and Risk Retaining/Acceptance (AS/NZS, 2004). As mentioned before, risk consists of two components probability and consequences. Therefore it is possible to affect the risk in two ways, treat the probability or the consequences. In this report RTO will be differentiated by moment of implementation, before or after the risk becomes a problem. According to Lam and Vickers (1997) there are two ways to apply RTO:

Pre-risk

Before the risk becomes a problem, in a preventative fashion.

Post-risk

After the risk becomes a problem, in order to try and contain the impact that the risk may have.

Examples of pre-risk options are housekeeping, maintenance, training and education. These treatment options are proactive measures to prevent the risk to be released. You could say these options assail the probability. Examples of post-risk options are automatic extinguish systems, fire detection and in-house fire brigade. These RTO aim to limit, reduce or abate the consequences from the risk when it releases. This report only considers the risk of fire or explosion.

3.4 Loss Prevention

Loss prevention is a very common phrase used in every production company and also frequently used within insurance companies all over the world. Loss prevention work is often a demand from an insurance company. To work frequently with loss prevention will consequently reduce the economical losses later on.

3.4.1 Fire Loss Prevention within SCA

The expression fire loss prevention is frequently used within SCA manuals, standards and guidelines. This expression should not be misleadingly associated with fire prevention or pre-risk options. One commonly used definition of prevention is “the action taken place before the risk becomes a problem”[5]. When entering the world of industries and insurances you suddenly realise the used word do not agree with the definition. The phrase “fire prevention” is often directing towards preventing larger losses and therefore there is no difference between pre-risk- and post-risk options. To be able to use material and documents from SCA, the differences between the expressions used

[5] The authors own definition.

within SCA had to be clarified. Definitions used in this report will agree with the expressions used within SCA. In this report fire prevention, loss prevention and fire loss prevention will be defined as:

Fire Prevention

An proactive intention to prevent fires to occur.

Loss prevention

An proactive intention to prevent larger losses to occur.

Fire loss prevention

An proactive intention to prevent larger losses caused by fire to occur.

Pre-risk options or fire prevention options[6] are thereby proactive treatment options implemented with intention to prevent fire to occur. Fire loss prevention options could on the other hand include both pre-risk options and post-risk options. When preventing a fire to occur you must stop the pre-fire development. When preventing a lager loss to occur it is possible to limit the pre-fire development.

It should be possible to prevent almost every fire, with the reason that most major accidents consist of human errors, component failures, organizational deficiencies or a combination of them. There are not many major accidents to be explained by a stochastic coincidence of independent events and thereby not preventable. Even if most accident could be prevented there will always be fires caused by the human factor. Human error plays roles from fifty percent to eighty percent and consequently it is very important to manage human error effectively to prevent losses. (Jo & Park, 2003). Fires costly preventable could be limited or reduced with post-risk options and therefore both pre- and post risk options are important.

3.4.2 Premium distribution

A premium distribution is the act of distributing the payment for insurance between the policyholders. All insurance companies make premium distributions. The distribution within industries is based on valuations made from inspections. Each insurance company decides for themselves which factors to valuate and compare. The distribution is often based on the policyholder’s risks and risk treatment.

3.4.3 Multiple Attribute Decision Making

Without further reference this text derives from Yoon & Hwang (1995).

Decision making may be exemplified as a process of choosing the best alternative from a selection. The alternatives are often characterized by multiple attributes. An example could be to select a car based on attribute price, speed, safety and comfort.

Multiple Attribute Decision Making, MADM methods is defined as:

“…making preference decisions (e.g., evaluation, prioritisation, selection) over the available alternatives that are characterized by multiple, usually conflicting, attributes.”

MADM procedures could be used in many ways, from automobile purchase or investment priority to a political decision. There are numerous MADM methods and Yoon & Hwang have identified 13. The MADM methods generally consist of two main phases. The first phase intends to identify and weight the attributes and the second to rank the alternatives to obtain the best one.

Identification

The most important issue within the identification is that the attributes represent the desired mission. One way of ensuring this is to derive the attributes from a super goal. If the super goal is too

[6] From now on, pre-risk options will be used with the same implication as fire prevention options because this report is limited to fire hazards.

abstract it could be useful to develop subdivisions. For example, if the super goal is “a good life” it is usually useful to go down the hierarchy until measurable goal/goals such as “income” is reached.

Weighting
The weighting is essential because not all attributes are likely to be considered equally important. The objective with the weighting is to express the importance of each attribute relative to the others. The weighting plays a key role in the MADM process and may vary from decision maker to decision maker or one decision situation to another. The most important aspect with the weighting is to reflect the purpose with the valuation. Hence, the weighting indicates which attribute the decision maker concerns most in a quantitative way. Consequently the weighting could be used to stimulate policyholders to make correct and adequate RTO investments. The decision maker may either use a cardinal or ordinal scale to express his or her preferences among attributes. Most MADM methods require cardinal weights normalised to sum to 1, expressed as:

$$\sum_{j=1}^{n} w_j = 1 \qquad (3.1)$$

where w_j is the weight assigned to the j th attribute.

Scoring
The second phase could be performed in several different ways and is the characteristic that differentiates the MADM methods. There are two methods possible to be used for scoring the alternatives, Simple Additive Weighting method and Weighted Product Method.

Simple Additive Weighting method
The probably best-known and most widely used MADM method is the Simple Additive Weighting, SAW method. Within the SAW method an alternative obtains scores by adding contributions from each attribute. To obtain the total score for each alternative the quantified valuation from each attribute is multiplied with the importance weight assigned to the attribute and then the products are summed over all the attributes. The value of an alternative is given by:

$$V(A_i) = \sum_{j=1}^{n} w_j v_{ij}, \qquad i = 1,.....,m \qquad (3.2)$$

where

$V(A_i)$	=	the value function of alternative A_i
w_j	=	the weight of the attribute X_j
v_{ij}	=	the value of the attribute X_j

The underlying assumption of the SAW method is that the attributes are preferentially independent. I.e. the value of an independent attribute is independent of all other attribute values.

Weighted Product Method
The alternatives in the Weighted Product Method, WPM method obtain scores by multiplying contributions from each attribute. The value of an alternative can be expressed as:

$$V(A_i) = \prod_{j=1}^{n} v_{ij}^{w_j}, \qquad i = 1,.....,m. \qquad (3.3)$$

where $V(A_i)$, w_j and v_{ij} are defined as above.

Because of the exponent property, WPM requires all attribute values to be greater than 1. Scores obtained by WPM do not have a numerical upper bound. It could be hard to find any true meaning in obtained values. If that becomes a problem it could be facilitated with comparing each alternative value with the ideal value. The ideal value is the value the ideal alternative scores when is assign maximal value at all attributes. The ratio can be expressed as:

$$R_i = \frac{V(A_i)}{V(A^*)}, \qquad i = 1,.....,m. \qquad (3.4)$$

where,

R_i = the value ratio between an alternative and the ideal alternative

V(A)* = the ideal alternative

$V(A_i)$, w_j and v_{ij} are defined as above.

The computational differences between the methods are that the WPM tends to punish low attribute values more strongly than the SAW method (Chang & Yeh, 2001). Consequently the SAW method scores alternatives with low valued attributes higher than the WPM. Accordingly the WPM is to prefer when wanting to avoid alternatives with any low valued attribute to be potential.

4 Analysis

4.1 Identification

The identification aims to identify attributes representing the fire loss prevention work within SCA. The identification of valuation factors is based on SCA Fire Loss Prevention Guidelines, FLP (2005), SCA Survey report manual, SRM (2003/2004) and several Survey reports from inspections of SCA plants. The main objective with the FLP is to raise each plant's fire loss prevention work to a generally approved level. The survey reports and manual underlie the present premium distribution.

The attributes are derived from the following main objective; *Raise the fire loss prevention work to a generally approved level.* To be able to identify measurable attributes a lower level objective is derived. The lower level objective is following; *Stimulate the plant Risk Managers to make correct and adequate RTO investments.* Measurable attributes[7] characterising this lower level objective are, within SCA, identified as risk treatment options.

No research or observation has been done at plants other than within SCA. The reason for the identification approach is the extent of model application. This model will be used primarily within SCA and therefore only factors relevant to SCA are studied. These valuation factors are consequently representative to plants within SCA and not necessarily more generally. It is possible to adjust the identification to other interested parties but will not be done in this master's thesis.

FLP (2005), SRM (2003/2004) and Survey reports made it possible to identify several factors that could be appropriate for premium distribution. The number of valuation factors appropriate for premium distribution is less than the number of factors important to fire loss prevention. Factors important to premium distribution are supposed to give just enough information about a plant's risk treatment to make the premium distribution possible. Factors important to fire loss prevention include on the other hand all factors with intention to prevent, limit, reduce or abate the risk of fire including the factors important to the premium distribution. The time limit made it impossible to identify and analyse every possible factor important to fire loss prevention. Consequently the identification and selection were made through systematic selection from surveyors and documents already available.

In order not to miss out any potential valuation factor the first identification intend to identify factors important to fire loss prevention. The first identification was made from FLP (2005) where each essential chapter was selected. A re-check were made through SRM (2003/2004) in order to identify every potential valuation factor. No further valuation factors were identified through SRM, only some name clarifications were obtained. A number of subchapters were identified as potential valuation factors through earlier written Survey reports and their following recommendation. The first identification resulted in 31 potential valuation factors and is made from the FLP (2005), the SRM (2003/2004) and earlier written survey reports. The complete list is documented in enclosure 1.

4.2 First selection

From the list of potential valuation factors the most important factors were to be chosen and further analysed. Criteria used at the first selection were:

- Importance to SCA fire loss prevention work
- Measurability
- Relevance to risk treatment
- General occurrence at the plants

From the list of 31 potential valuation factors 19 were chosen and further analysed. The selected factors from the first selection are shown in table 4.1. The selection was made in agreement with

[7] From now on the attributes are named valuation factors.

the SCA Group Risk Manager. Some of the valuation factors were to be processed and renamed before the final selection. Renamed and processed factors are documented in enclosure 2.

Identified factors	
Risk Management	Fire Separation
Self inspections and maintenance of existing plant facilities	Fire risk awareness – Training and education
Building construction	Manual fire fighting equipment
Public and in-house fire brigade	Fire detection and alarm
Fire evacuation	Automatic extinguishing system
Housekeeping	Security and access control
Impairment procedures	Emergency and continuity plans
Hot work permits	Smoking regulation
Control of external contractors	Fire hazard analysis routines
Incident reporting	

Table 4.1 First selection

4.3 Final selection

The final selection was made through four interviews and a group discussion with SCA Group Risk Manager and Risk Manager Loss Prevention.

4.3.1 Interviews

The purpose with the interviews was to make the selection of the factors possible and to validate the questionnaire[8]. The interviews were arranged with four persons with different experience of fire loss prevention and SCA plants. Their occupations were; Risk Manager, Health-, Safety- and Security Manager, Risk Engineer at an external insurance company and Fire Engineer consult with earlier experience of paper industry and SCA plants. The interviewees were selected to represent as much experience as possible and to correspond to the variety of persons filling out the questionnaire.

Before the interview started the questionnaire was filled in. The situation corresponded as much as possible to the situation when the other questionnaires were filled in. The interviewees were not given any further information beyond the flyleaf before filling in the questionnaire. A structured interview format was adopted to achieve needed information (Andersson, 1985). The question needing an answer was:

Which factors should underlie SCA's premium distribution?

To get the answer to the question, each valuation factor from the first selection was studied. The interviewees were asked three questions for each factor:

1) Is there anything imprecise about the formulation of this factor or is there something you would like to enquire about?
2) Should this factor be included in SCA's premium distribution?
3) Why or why not?

After studying each factor a final question was asked:

4) Is any factor lacking?

[8] See chapter 4.7.1Questionnaire.

Question number 1 aimed of validating the questionnaire. The answer to question number 1 is documented together with the two other and there were no observed misunderstandings to the definition of the factors. Question number 2 could be answered with yes or no and question number 3 gives the interviewee a chance to motivate the answer. Mostly the interviewees avoided yes or no at question number 2 and answered with the motivation immediately.

According to Andersson (1985) recording could affect the answer from the interviewees and therefore only written notes were made throughout the interviews. Because of the structured interview format there was no need to use a tape recorder. There was no problem to take notes from the questions. Some of the interviewees even made their own notes on the questionnaire while the interview. Immediately after each interview the notes were written out fair in order to avoid any kind of misunderstandings.

All answers from the interviewees are mixed and presented jointly under each question with the reason to keep the interviews as anonymous as possible. This could consequently give the reader a slightly more diffuse picture of the answers. The interview answers are documented in enclosure 3.

4.3.2 Group meeting

When the interviews were compiled, a group meeting with the Risk Management department in Stockholm was carried through. Based on the compiled interviews, each factor was discussed and the final selection was made. Nine factors were dropped after the interviews and group meeting. The final selection resulted in ten valuation factors with objective to underlie the premium distribution within SCA. Criteria used at the final selection were:

- Original criteria from the first selection,
- Independence from the other factors and
- Probability of objectivity at the valuation.

The selection was made from the compiled interviews and experience from SCA Group Risk Manager and Risk Manager Loss Prevention. The final selection was more restrictive than the first with the objective to reduce the factors to a manageable number. The meeting started with going through the results from the interviews. After each factor a decision was made whether the factor should be selected or dropped.

4.4 Selected valuation factors

The selected factors were assigned explanations according to FLP (2005).

Risk Management

Risk Management is composed of several coordinated activities to direct and control an organization with regard to risk.

Security and access control

Security and access control aims at reduce the risk of arson by preventing unauthorized persons to enter the site unattended. For example fences, floodlights, irregular watch guard inspections, etc.

Automatic extinguishing system

An automatic extinguishing system aims to put out the fire in an early stage or at least reduce the fire and limit the fire spread.

Public and in-house fire brigade

The public and in-house fire brigade aims to increase the chances of a fast and effective fire fighting intervention with a view to save lives and keep the business continuity alive.

Fire separation

Fire separation within and between buildings aims to limit the consequences of damage in case of a fire.

Manual fire fighting equipment
Manual fire fighting equipment aims to makes it possible for the employees to extinguish a fire in an early stage.

Hot work permits
Hot work permits aim to prevent fire incidents, for example routines, education, practice, guidelines and rules.

Impairment procedures
Impairment procedures aims to makes sure that the safety level remains sufficient when a sprinkler system or any other vital fire loss prevention installation is out of service.

Self inspection and maintenance of existing plant facilities
Regular self-inspections aims to check and make sure that the fire hazards are kept on a low level and all protection systems are in good working condition and maintained.

Fire detection and alarm
Fire detection and alarm aims to receive an early warning with a view to evacuate, manual fire fighting and immediately inform nearest fire brigade.

4.5 Dropped factors
Fire risk awareness – Training and education
It is a very important factor but too difficult to measure. The valuation would be too subjective. It is possible to value the factor through documentation of training and education but it would not say much of the quality of present fire risk awareness.

Housekeeping and Smoking regulations
Housekeeping and Smoking regulations are both included in other factors as Self-inspection and maintenance of existing plant facilities. It will be too difficult to valuate them by themselves as separate factors.

Control of external contractors
This is an important factor but it is difficult to measure its present state. It should be included in the basic demands and taken for granted[9].

Incident reporting
This is an underlying factor that takes expression in many other ways. Incident reporting is for example a base for continuous improvement and thereby affecting Risk Management. Risk Management will be included in the model and consequently Incident reporting will not be a separate factor.

Fire hazard analysis routines
As with the incident reporting this is a fundamental factor underlying many other factors and will thereby not be included in the model.

Fire evacuation
There is no need to make demands on Fire evacuation because there are always high quality demands in other laws and regulations. Fire evacuation will therefore not be included in the model.

Emergency and continuity plans
This factor is very important with the purpose of reduce economical losses. SCA want to call attention to factors with intention to prevent the losses, not to reduce them and therefore the factor will not be included in the model.

[9] Take for granted means SCAF should not need to demand this; all plants should keep the same basic level without further demands from SCAF.

Building construction
SCA insurance company strives to the best for the entire SCA and not only for the insurance company. The building construction is not something the plants could affect afterwards and therefore not included in the model.

Electrical protection
This is an important factor mentioned at the interviews. The factor should be included in Self-inspection and maintenance of existing plant facilities and will thereby not make an independent factor.

Others
EML, Risks without fire occurrence and Fire load were mentioned at the interviews and is of course of great importance to an insurance company. This report is limited to risk treatment options[10] and will not consider if EML, Risks without fire occurrence or Fire load should be taken into account or not. It is possible to revise the model and include EML or other factors considered important, later on.

4.6 Classification

Selected valuation factors were classified in order to facilitate the risk communication to the plant managers. The intention with the classification is to divide the factors by the moment of implementation, before or after the risk becomes a problem. According to Lam and Vickers (1997) there are two ways to apply risk treatment, as pre-risk options or post-risk options. Consequently the classification compartmentalise the factors into two groups; pre-risk options and pre-risk options.

4.6.1 Pre-risk options

Risk Management is a very important pre-risk option that also includes post-risk options. The main focus of SCA's Risk Management is to prevent the risks before they turn into problems. The Committee of sponsoring Organizations of the Treadway Commission [COSO] (2003) considers the definition of Enterprise Risk Management[11] to reflect certain fundamental concepts. Three of the concepts are, Risk Management:

- is *a process* – it’s means to an end, not an end itself.
- is *effected by people* – it is not merely policies, surveys and forms, but involves people at every level of an organization.
- is *applied across the enterprise*, at every level and unit, and includes taking an entity level portfolio view of risks.

These concepts stress the importance of a good Risk Management culture being built into the plant’s infrastructure. Risk Management should be a part of the essence and consider activities at all levels of the organization. With regard to these concepts, Risk Management considers to be classified as pre-risk option.

Self-inspection and maintenance of existing plant facilities is a pre-risk option. Inspection and maintenance of other post-risk options as fire detectors and extinguishing systems exist but it is not the main purpose of this factor. Self-inspection and maintenance are classified as a pre-risk option.

Impairment procedures aim, as mentioned, to make sure that the safety level remains sufficient. Thereby it will be classified as a pre-risk option.

Hot work permits aim to prevent fire incidents and are classified as a pre-risk option.

Security and access control aims to prevent fire occurrence caused by arson and will be classified as a pre-risk option.

[11] Risk Management will be used with the same implication as enterprise Risk Management.

4.6.2 Post-risk options

Public and in-house fire brigade, *Fire separation*, *Fire detection and alarm*, *Automatic extinguishing systems* and *Manual fire fighting equipment* are treatment options acting after the risk becomes a problem and thereby classified as post-risk options.

4.7 Weighting

Identified factors are of different importance to SCA's fire loss prevention. For example may Security and access control not be as important as Risk Management. Risk Management affect the entire fire loss prevention work, while Security and access control almost only prevent arson. There are several ways to weight the factor's importance according to fire loss prevention. You could for example use statistics from Incident and Accident Reporting, examine Risk Analyses or questioning persons with experience. The expression "incident" is unfortunately used synonymous with "accident" within SCA. Information from incident and accident reporting is consequently of limited use for this purpose. To examine Risk Analyses is a very good approach to identify the most important factors. This is unfortunate a very time-consuming work, unless already available. Consequently, the weighting is based on persons with experience. The choice of method became thereby a questionnaire.

The weighting in this report is based on the factor's importance to fire loss prevention. Another alternative is to analyse the factor's importance to premium distribution. A factor's importance to fire loss prevention does not always coincide with a factor's importance to premium distribution. Some factors are more important to the one or the other. Premium distribution is often based on the result of the loss prevention work and not on how to get there. Fire hazard analyses and incident reporting are for example underlying factors important to fire loss prevention. They are on the other hand seldom valuated independently within premium distribution.

SCAF has a different objective from the majority of insurance companies. SCAF strives for reducing all costs from losses within the entire SCA, while other insurance companies mostly are interested in reducing costs not covered by the excess. Accordingly I chose making the weighting from importance to fire loss prevention and not from importance to premium distribution.

4.7.1 Questionnaire

Layout

The questionnaire intended to measure the relation between selected valuation factors according to fire loss prevention. According to Andersson (1985) the initial instruction is very important and should be clear and distinct. Accordingly, the flyleaf informed the participants about the purpose of the study, how the results will be used and how to fill in the questionnaire. Before the scoring started some questions about age, sex, occupation and experience were asked. The questionnaire was of simple design and included all of the 19 factors identified at the first selection. The reason for that was that the questionnaires had to be sent out before the final selection was finished. Only the results from the ten factors from the final selection will be analysed and taken into account.

When asking a number of questions with the same answering techniques Andersson (1985) recommend using the opposite-question-technique[12]. When striving for a valuation of the questions Andersson recommends an Osgood-scale. The Osgood-scale and the opposite-question-technique make it possible to sum up each question and compare the answers to each other without further process. In accordance to Andersson (1985) the mentioned technique was chosen and used in order to establish a scoring and weighting of the valuation factors. The overriding question was "How important are these factors to fire loss prevention?" The questionnaire was developed as shown in figure 4.2.

[12] Author's translation.

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Fire separation												
Fire separation within and between buildings aims to limit the consequences of damage in case of a fire.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Impairment procedures	0	1	2	3	4	5	6	7	8	9	10	I don't know
An impairment procedure aims to makes sure the safety level remains sufficient when a sprinkler system or any other vital fire loss prevention installation is out of service.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Figure 4.2 Questionnaire illustration

Each factor was assigned an explanation to make sure that the participants understood and answered the same question and thereby increasing the validity. The complete questionnaire is documented in enclosure 4.

Participants

Persons filling out the questionnaire must be experienced within fire loss prevention work and therefore some participation rules were made before sending out the questionnaire. The participation rules were made in confers with SCA Group Risk Manager and Risk Manager Loss Prevention. The fundamental criteria for participation were experience to fire loss prevention work. To be able to participate, one of following participation rules was to be fulfilled:

- Present occupation within SCA-industry preferably within the Risk Management sector,
- Present occupation as a Risk Engineer within an external insurance company, with experience of SCA plants,
- Extended external experience of Risk Management within paper industry, or
- Work at SCA's insurance department.

The questionnaire was delivered to 28 persons of who two did not return the questionnaire. One of them went on vacation and the other did not consider himself to be experienced enough to participate. All other completed the questionnaire.

Twelve of the participants were randomly selected when visiting the plants. The others were randomly selected within their occupation group. Visits were made at Ortviken Paper Mill, Östrand Pulp Mill, New Hythe Liner Mill and Aylesford.

All Risk Managers within SCA's insurance department, several Risk Engineers, Underwriters, Risk Manager consultants, Security Managers and Fire Engineers participated in the study. All except one participant have more than six years international experience of fire loss prevention work; most of them with experience from different occupations. As a consequence of this 81 % of the participants were 50 years old, or older.

Validity

The validity intends to state if the questionnaire measures what it aims to measure (Ejvegård, 2003). One way of increasing the validity is testing the questionnaire before usage (Andersson, 1985). The test is supposed to be done with persons equivalent to the selected persons. In accordance with Andersson the questionnaire were tested and rearranged before usage to give usable answers.

The tests were done with two persons with experience equivalent to the selected persons. At the test, the person was asked to complete the questionnaire in peace and quiet. The person was allowed to comment any question difficult to interpret. The person was watched while the questionnaire was filled in, in order to identify if he/she did as the flyleaf requested or if he/she had problem with any question. Afterwards the person was asked to comment each and every question in order to identify if he/she interpreted the question as mentioned.

The most important change concerned the main question. Before the test the question was “How important are these factors to premium distribution?” and after the test “How important are these factors to fire loss prevention?” The first question meant to be answered within the interviews and not through the questionnaire. The test resulted in clearer and more distinctive formulation of the Risk Management. The questions in the questionnaire were also rearranged because one of the test persons did not read through all the questions before starting to complete the questionnaire. The read through intends to prevent the person from changing reference while he/she completed the questionnaire. The purpose of the questionnaire is to score each factor relative to the others and if the person starts to answer the first question before knowing what the others are he/she cannot compare them to each other and give them an appropriate score. The ordering of the questions in the subsequent study was consequently performed in four different ways. Completed questionnaires used in the test are not used in the report. Three weeks after the test the test persons completed new questionnaires that were used in the study. The reason for this is that the test persons are important decision makers within SCA and their votes must somehow be included in the study.

Other smaller and less generally accepted validity tests were performed continuously throughout the study. 15 of the persons in the study were observed when completing the questionnaire. The persons were invited to ask questions if there were any doubts about the questionnaire or the questions. None of the 15 persons asked questions and there were only two persons not reading through the questionnaire before answering. The only given comments were about how difficult it was to give a quantitative value and compare the factors to each other. Four of the observed persons were interviewed concerning the selection of factors. These four persons were asked to comment each question in the questionnaire in order to make sure they interpreted the question correctly. No one had problems with understanding the questions correctly, but all of them had different experience of the quality of the valuation factors. The occasional talk about experiences mentioned in the interviews is not documented in the report. The reason for this is that the information is not needed for this report and the notes from the interview were only concentrated to information about the factors existence.

Reliability

The reliability states the trustworthiness and the usability of used measurement (Ejvegård, 2003). The gauge in this study intends to measure the relation between the factors and not how important each factor is. It is almost impossible to give an absolute answer to the question of how important each factor is to fire loss prevention. The only answer this study gives is a relatively answer of how important the factors are relatively to each other. As a result of this relative measurement the discussion about “what 0 means and what is 10 worth” is avoided. Each person uses the gauge in his or her own way. The study gives no generally accepted answer to the relation between the factors outside SCA. The usability of the weighting result is limited to SCA plants.

4.7.2 Order of importance

The results from the questionnaires gave selected valuation factors a point value based on their importance to fire loss prevention. Based on the point value the factors were arranged in their order of importance.

It is possible to ensure significant difference through an estimation of the confidence interval for the mean of the factors difference (Körner & Wahlgren, 2002). Following formula was used attempting to ensure a difference between the valuation factors:

$$\frac{1}{n}\sum d \pm z\left(\frac{s}{\sqrt{n}}\right), \qquad (4.1)$$

where d difference between each person's answer to factor j and j+1

z 1,96 to 95 % confidence level

s standard deviation of d

n size of sample

The formula is limited to, large enough, normal distributed samples. If the confidence interval for the mean of the factors difference includes the number zero, the two factors are not significantly different (Körner & Whalgren, 2002).

Each participant used the scale from 0 to 10 in their own way and therefore the scales were calibrated to each other. Each participant's given points were calibrated to the total mean value. The calibration makes given points comparable to each other.

The calibrated points were analysed in the same way as the ordinary points without further progress. Nor the calibrated points could guarantee significantly difference. The calibration and analyse is documented in enclosure 5. Even if the factors cannot be guaranteed significant different the result gives a value of the factors importance to fire loss prevention. The received point values are the result of years of experience from the participants answering the questionnaire and will irrespectively underlie the weighting. The weighting is calculated from the equation 3.1 in chapter 3. The weighting used in the model is based on the calibrated point values. Each factor's calibrated point value, mean value and weight are shown in table 4.3.

Valuation factors	Point value	Mean value	Weight
Automatic extinguishing system	251,53	9,67	0,12
Fire separation	233,84	8,99	0,11
Risk Management	229,06	8,81	0,10
Hot Work permits	227,22	8,74	0,10
Self inspection and maintenance of existing plant facilities	226,55	8,71	0,10
Fire detection and alarm	220,00	8,46	0,10
Public and in-house fire brigade	208,74	8,03	0,10
Impairment procedures	206,05	7,92	0,09
Manual fire fighting equipment	203,76	7,84	0,09
Security and access control	174,26	6,70	0,08

Table 4.3 Weighting

4.8 Valuation and quantification

To be able to make the valuation possible, each factor is assigned four valuation levels, Very good, Good, Fair and Poor. Too many or too few valuation levels make the valuation difficult. Five valuation levels make the valuation complex and time-consuming. With three valuation levels, the middle value does not take stand about the quality of the valuation factor. Four valuation levels are usable and force the valuator to take a stand. The valuation maker is forced to decide whether to go with or against the statement and there is no intervening valuation level to choose when uncertain (Andersson, 1985). In order to measure the quality of the valuation factor the valuation levels are quantified with 1, 2, 3 and 4, where 1 represent Poor and 4 represent Very good, as shown in table 4.4.

4.8.1 Criteria

In order to make the valuation more objective, each valuation level should be assigned a number of criteria. To receive the valuation Very good the plant must fulfil all criteria assigned the valuation level Very good. All criteria must be fulfilled for each level, the levels below and no exceptions are accepted.

In order to facilitate the identification of criteria, a Criteria guideline was adopted. The guideline is derived from the PDCA-cycle and strives for continuous improvement. To be able to use the valuations in the final valuation the valuation levels are quantified with the number 1 to 4, were 4 represent Very good.

Valuation level	Qualification	Criteria guideline
Very good	4	All recommendations in the FLP are followed. Procedures are integrated into the culture of the organisation and the plant is always one step ahead of present FLP. Continuous improvements are ensured.
Good	3	The PDCA-cycle is started but not frequently repeated. Continuous improvements are not completely ensured.
Fair	2	The objective with the RTO is identified and carried through without reflecting the quality of the results.
Poor	1	None of the higher valuation levels are fully achieved.

Table 4.4 Criteria guideline

In this master's thesis example of criteria is given to each level and factor. The criteria assigned each level are based on the FLP (2005) with the exception of Risk Management. Recommendations, objecting Risk Management is not included in the FLP. The criteria, assigned Risk Management, are therefore based on chapter 3.2 Risk Management. All criteria are individually adjusted and specified to each valuation factor. The criteria were identified and selected in confer with SCA Group Risk Manager, Risk Manager Loss Prevention and Risk Manager Hygiene Products.

The top valuation (Very good) is only given to plants, one step ahead of the recommendations in the present FLP and continuous improvements are ensured within the entire organisation. Effective programmes and procedures have been implemented into the culture of the organization in order to keep the RTO on a generally accepted level.

The valuation Good is given to plants, where the result of the implemented risk treatment option is checked, in order to identify the quality and benefit. The PDCA-cycle is started but not frequently repeated. Consequently, continuous improvements are not ensured. Insignificant deviation from the recommendations in the FLP exists and the most important criteria are the same as for the valuation level Very good.

The valuation Fair is given to plants where the objective with the RTO is identified and carried through without reflecting the quality of the results. In the same way as with Very good and Good the most fundamental criteria from the valuation level Good are repeated at the valuation level Fair.

The valuation Poor is given to plants where none of the higher valuation levels are fully achieved.

The criteria assigned Risk Management are based on what representing good Risk Management and the PDCA-cycle. When combine the PDCA-cycle with important characteristics indicating good Risk Management, four essential phases were identified:

Phase 1: Planning, identifying and developing Risk Management activities (Plan), Phase 2: Establishing Risk Management and its context (Do),

Phase 3: Practising integrated Risk Management (Check), and

Phase 4: Evaluation of the process and ensuring continuous improvements (Act).

These phases are assigned criteria and converted into Very good, Good, Fair and Poor to fit the valuation model.

4.9 Final valuation

After having assigned each factor an individual weight and value they are combined and summed in order to reflect each plant's risk treatment. The weights range from 0,115 to 0,080 reflecting the purpose of the valuation. The valuation accord with the valuation levels Very good, Good, Fair and Poor, quantified as 4, 3, 2 and 1 respectively. As mentioned in chapter 3.4.3 the SAW method obtain scores by adding the contributions from each factor. The other potential method is the WPM, which multiply the contributions from each attribute instead of adding. According to Chang & Yeh (2001) the computational differences between the methods are that the WPM tends to punish low valued factors more strongly than the SAW method. For that reason used method in this model should preferably be WPM. To possess low valued factors should bring the most punishments. Both methods were analysed to find the most suitable method.

Scores were calculated from formula (3.2) and (3.3) as shown in table 4.5. No problem occurred with interpretation of received WPM values, consequently no ratio between the scored factors and the ideal score where needed. Calculated scores aim to give a comparatively and quantitative value to each plant and is called Loss Prevention Point, LPP. Each plant's LPP is supposed to underlie the premium distribution within SCA. The better, more correct and adequate fire loss prevention work the better LPP.

Loss prevention point, LPP

	Factor 1		***Factor 2***		***Etc.***	***WPM*** $V(A_i)=\prod_{j=1}^{n} v_{ij}^{w_j}$		***SAW*** $V(A_i)=\sum_{j=1}^{n} w_j v_{ij}$	
	Valuation (v_{i1})	Weight (w_1)	Valuation (v_{i2})	Weight (w_2)					
Plant 1	4	0,115	4	0,107	…	4,0	(Max)	4,0	(Max)
Plant 2	3	0,115	3	0,107	…	3,0		3,0	
Etc.	2	0,115	2	0,107	…	2,0		2,0	
	1	0,115	1	0,107		1,0	(Min)	1,0	(Min)
	4	0,115	3	0,107		3,5		3,5	
	3	…	4	…		3,5		3,5	
	3		2			2,5		2,5	

Table 4.5 Scores from MADM methods.

Both methods provides LPP's in the range from 4 to 1 which means the plant with optimal fire loss prevention work is given four times the value of the worst possible. The analysis poorly supported Chang & Yeh (2001) statement; the WPM punishes low valued factors more strongly than the SAW method with no significant difference. The complete analysis is documented in enclosure 6. According to Yoon & Hwang (1995) the WPM has not yet been widely utilized and the SAW method is the best-known and most widely used MADM method. Consequently the SAW method is used in the model.

5 Results

The identification resulted in ten selected valuation factors. The valuation factors aimed to be appropriate for premium distribution and represent the quality of the fire loss prevention within SCA. The selected valuation factors were classified as pre-risk and post-risk options and assigned weights according to their importance to fire loss prevention. The classification, weighting and order of rank are shown in table 5.1.

Selected valuation factors	Weight	Order of rank
Pre-risk options		
Risk Management	0,115	1
Self inspection and maintenance of existing plant facilities	0,107	2
Impairment procedures	0,101	6
Hot Work permits	0,094	8
Security and access control	0,093	9
Post-risk option		
Public and in-house fire brigade	0,105	3
Fire separation	0,104	4
Manual fire fighting equipment	0,103	5
Fire detection and alarm	0,096	7
Automatic extinguishing system	0,080	10

Table 5.1 Pre-risk options.

In order to make the valuation possible, four valuation levels were established; Very good, Good, Fair and Poor. The valuation levels should be assigned criteria adjusted to each valuation factor in order to make the valuation more objective. In order to facilitate the assignation of criteria a Criteria guideline is adopted, shown in table 5.2.

Valuation level	Qualification	Criteria guideline
Very good	4	All recommendations in the FLP are followed. Procedures are integrated into the culture of the organisation and the plant is always one step ahead of present FLP. Continuous improvements are ensured.
Good	3	The PDCA-cycle is started but not frequently repeated. Continuous improvements are not completely ensured.
Fair	2	The objective with the RTO is identified and carried through without reflecting the quality of the results.
Poor	1	None of the higher valuation levels are fully achieved.

Table 5.2 Criteria guideline.

The guideline is derived from the PDCA-cycle and strives for continuous improvement. To be able to use the valuations in the final valuation the valuation levels are quantified with the number 1 to 4, were 4 represent Very good.

In this master's thesis an example of criteria is given to each factor and valuation level. The criteria are shown in enclosure 9. The example of criteria given in this master's thesis is based on the Criteria guideline and intends to reflect valuation levels usable within SCA.

5.1 The LPP-model

The LPP-model is adjusted to SCA and based on the ten selected valuation factors and their weights. By using the identified criteria examples, the plants will achieve objective values to each and every of the ten valuation factors.

In order to measure the quality of the fire loss prevention work the quantitative valuation is used as input to the model, and consequently the LPP-model generates a value of risk treatment. The received LPP value is a relative value objecting a comparison between the plants quality of risk treatment.

LPP-model

	Factor 1				***Factor 2***				***Etc.***		
	Valuation (v_{i1})		Weight (w_1)		Valuation (v_{i2})		Weight (w_2)			**Loss Prevention Points (LPP)**	
Plant 1	4	x	0,115	+	4	x	0,107	+	…	4,0	(Max)
Plant 2	3	x	0,115	+	3	x	0,107	+	…	3,0	
Etc.	2	x	0,115	+	2	x	0,107	+	…	2,0	
	1	x	0,115	+	1	x	0,107	+		1,0	(Min)
	4	x	0,115	+	3	x	0,107	+		3,5	
	3	x	…		4	x	…			…	
	3	x			2	x				…	

Table 5.1 The LPP- model.

The LPP-model combines the factors individual weight and value by using the SAW-method. The SAW-method obtains scores by adding the contributions from each factor. The plants receive scores (Loss Prevention Points) varying from 1 to 4, where 4 is the maximal scoring.

5.2 Uncertainties

The model and its results are, as any model, involved with uncertainties. De most prominent uncertainties, that been identified, are likely derived from:

- the in-put or/and the usage of the model,
- the SAW-method, and
- the weighting.

Uncertainties derived from the in-put or/and the usage of the model could differ between each plant and would consequently entail opposing and divergent results. The extent of the uncertainties depends on the quality of the in-put and the correctness of the model usage. In order to minimize the uncertainties it would be to prefer to use the same valuation maker to valuate all comparative plants. That is unfortunately not practicable and consequently each valuation factor is assigned valuation criteria in order to reduce the uncertainties involved with various valuation makers. The usages of the criteria in the valuation process intend to reduce the divergence in the result. The valuation criteria aim at make sure that the valuation will be based on the same underlying valuation reasons and thereby reduce the uncertainties.

Uncertainties derived from the SAW-method are the same for every valued plant and entail no opposing or divergent result between different plants.

Uncertainties derived from the weighting could differ between each plant and could consequently entail opposing and divergent results. In order to analyse the influence of the weighting a sensitivity analysis is made.

5.2.1 Sensitivity analysis

The aim of the sensitivity analysis was to examine the influence of the weighting. Received weighting and ranking are as follow:

Factors classified as Post-risk option	Weighting (order of rank)	Factors classified as Pre-risk option	Weighting (order of rank)
Automatic extinguishing systems	0,115 (1)	Risk Management	0,105 (3)
Fire separation	0,107 (2)	Hot work permits	0,104 (4)
Fire detection and alarm	0,101 (6)	Self inspections and maintenance of existing plant facilities	0,103 (5)
Manual fire fighting equipment	0,094 (8)	Impairment procedures	0,096 (7)
Public and in-house fire brigade	0,093 (9)	Security and access control	0,080 (10)
Sum:	0,511	Sum:	0,489

Table 5.2 Used weighting with actual ranking

Table 5.2 shows that the weighting favour post-risk options with a slightly difference. The sensitivity analysis showed, no more than a slightly difference in the model result, see enclosure 7.

5.2.2 Reality study - Applicability study

The aim of the reality study was to examine the applicability of the LPP-model. The reality study included the valuation of two plants made by an experienced valuation maker.

Valuation points received from the reality study were used as input to the LPP-model and documented in enclosure 8.

Plant	Model result	The valuation maker's subjective judgement
Plant 1	2,7	A SCA plant with insufficient Loss Prevention and poorly performed Risk Management.
Plant 2	3,9	A SCA plant with one of the best performed Risk Management and Loss Prevention.

Table 5.3 Case study result.

The reality study showed that the LPP result corresponded to the valuation maker's subjective judgment, even though the reality study implies an overestimation of the plants of the quality of fire loss prevention. Consequently the model gives no room and possibility to reward further improvements. It will be difficult to motivate a plant with already high scores to make improvements; what difference will it make to strive for improvements if you already have the highest score? The valuation level 4 (Very good) should not be distributed frequently if the criteria are used and defined correctly. Consequently the criteria must be used with further carefulness, clarified or modified in order to represent the existing fire loss prevention level within SCA.

If further usage shows that the valuation level 1 never is used and level 4 is used frequently, the criteria examples must be modified in order to represent the risk treatment level within SCA. If the LPP model continuous to give results near 4,0 a modification and adjustment of the valuation levels is to be considered.

6 Discussion

As mentioned before, all models including the current one, contains assumptions and limitations. The established LPP-model in this master’s thesis is adopted and limited to SCA insurance company. The used method might on the other hand be appropriate to other insurance companies or interested parties. One of the most affective assumptions is that the RTO's are the only attributes representing the quality of the fire loss prevention work. It is assumed that the quality of the fire loss prevention work is not influenced by the initial or residual risk. Consequently all plants will be valued with the same criteria irrespectively of the size of their risks. If the size of the risk need to be included in the premium distribution it is possible to adjust the LPP afterwards.

The usage of the LPP-model established from the method in this master’s thesis is limited to plants within SCA and must be revised continuously. If the LPP-model will be used outside SCA the model must be adjusted to the new conditions. The method is possible to use if the identification, weighting and valuation criteria are adjusted to the new demands, preferences and objectives.

6.1 Method used

The method used in this master’s thesis is based on and adjusted to the field of application within SCA. The selected approaches are supposed to be the most appropriate according to the field of application. SCA strives to stimulate and praise good work instead of criticize imperfections and that is what underlie the approach and selected method. Each step is discussed in following chapters.

6.2 Identification

The identified valuation factors intend to reflect SCA's most important risk treatment options. Together, these factors intend to represent the quality of each plant’s fire loss prevention work. Most important with the valuation factors is that they represent correct and adequate RTO investments determined by the Risk Management function.

The valuation factors are mostly identified through the FLP (2005). If SCA missed out any important factor in the FLP (2005) the factor will be missing in the model. The interviews reduced the possibility of any missing factor even if the possibility still exists. The FLP (2005) is the present guideline for all plants within SCA, published by SCA Risk Management function. The main objective with the guideline is to raise each plant’s fire loss prevention work to a generally approved level. As soon as FLP (2005) revises the identification must be adjusted. Otherwise important valuation factors will be missing in the model. All identified factors in this model coincide with the FLP (2005) and are of great importance to SCA at the present state. Factors representing correct and adequate RTO investments change with time and the identification must continuously be revised to represent the present state. When revising selected valuation factors it is important to keep the usability in mind. The number of selected factors must be practicable. Furthermore, it is important that no factor is independent at the same time as they are included in other factors.

The consequence of an important valuation factor missing is that the scored LPP will be incorrect and perhaps misleading. One factor that was mentioned at the interviews was “Other significant features”. The factor aims to make it possible to value factors missed out through the identification. Unfortunately, this factor was not weighted together with the other factors and therefore not possible to use in this model. The factor could possibly be included in the model with the next model revision. A suggestion of explanation and assigned criteria to the factor is documented in enclosure 10.

Another valuation factor mentioned at the interviews was Estimated Maximum Loss, EML. This factor is important to premium distribution but not to the quality of the fire loss prevention work. The objective with this master’s thesis is to give a value of the quality of the fire loss prevention work and therefore the EML will not be included in the model. It is on the other hand possible to add this, or other factors, to the LPP's after the scoring and before making the premium distribution.

6.3 Dropped factors

The dropped factors that are included in other factors are important to be considered and accounted for when valuing selected factors. Concerned factors of great importance are “Fire risk awareness – Training and education”, “Housekeeping and smoking regulations” and “Electrical protection”. It is important that these factors are included and valued approximately within other factors.

6.4 Classification

The classification does not affect the results from the model. The classification only intends to facilitate the risk communication to the plant risk managers.

6.5 Weighting

The weighting is based on “importance to fire loss prevention” and not on the premium distribution. This assumption can unfortunately not be proved correct. These two expressions are frequently used with the same intention. Insurance companies often intending the factors included in the premium distribution model as the only factors important to fire loss prevention. This is as mentioned before not the truth. The truth is that there are lots of factors important to fire loss prevention with insignificant importance to premium distribution, exemplified by fire evacuation. The value of a human life is not always included in the premium distribution but has always a great value to the policyholders.

The participants could easily mix up “importance to fire loss prevention” with “importance to premium distribution” when completing the questionnaire. The importance of completing the questionnaire with the right objective was strongly declared and the participants were all consent to the objective when starting completing the questionnaire. Due to the two closely related expressions, total lack of influence of importance to premium distribution cannot be ensured. Fortunately the most important of the weighting process is the reflecting of the decision maker’s preferences and intentions. The weighting from the questionnaire completely comply with the decision maker’s intention and thereby the possibility of influence of importance to premium distribution do not affect the usage of the model.

What 0 means and what 10 is worth could differ from one person to another. One person could have used only the numbers 5 to 10 at the same time the second person only used the numbers 1 to 5 and the third maybe used the entire scale. With the reason that each person used the gauge and scale in his or her own way the calibration was needed. In this case the calibration of the questionnaire result affected the weighting insignificantly. Table 6 shows the comparison between the weights calculated from the mean value and the calibrated mean value.

Valuation factors	**Weight**	
	Mean value	Calibrated mean value
Automatic extinguishing system	0,113	0,115
Fire separation	0,107	0,107
Risk Management	0,105	0,105
Hot Work permits	0,105	0,104
Self inspection and maintenance of existing plant facilities	0,105	0,104
Fire detection and alarm	0,101	0,101
Public and in-house fire brigade	0,095	0,096
Impairment procedures	0,094	0,094
Manual fire fighting equipment	0,095	0,093
Security and access control	0,081	0,080

Table 6.1 Valuation factors with weights.

An alternative to the weighting is to make the participants give the valuation factors an order of rank. The quantification could then be made straight from the ranking. This would make it possible to avoid the difficulty to secure significant difference between the factors. Instead there would be difficulties to decide which weight the highest ranked factor should have relatively to the lowest. This was not a feasible alternative, because the questionnaire was sent out before the final selection was carried through. Consequently the questionnaire contained 19 valuation factors, which were too many factors to require an order of rank. Accordingly, the simplest and most widely used way of making the weighting was used, through value points.

All selected valuation factors are important to fire loss prevention and used method made it possible to give all factors high points. Only three participants used the lower grading of the scale[13] and therefore all factors receive high points. Consequently there was no possibility to secure any significant difference between the factors. The lack of secured significant difference does not affect the result when using the weight and not the order of rank. The LPP is directly dependent on the weights and not on the relative order of the factors. The weights should always be up to date and revised at the same time as the intention or the preferences change. If the decision makers want to stimulate improvement within a specific treatment option the weighting could be updated and changed in order to increase the motivation.

There are lots of aspects affecting the valuation of the factors importance to fire loss prevention. The presumably, most affective aspect is the participant's own experience of the factors. Other aspects affecting the valuation are geographic location, environment and risk category. Security is for example much more important in countries or environments were arson occurs frequently. The weighting intends to reflect the widely different values of the factors in order to get a generally functional weighting. The model intends to be general and overriding and therefore the more widely different experiences and aspects affecting the valuation the better the weighting will be. If the participants all came from the same country with the similar experience the weighting would not be generally functional to all SCA plants.

The valuation is furthermore affected by the interaction between the factors. The value of Automatic extinguishing system is for example higher if public or in-house fire brigade is lacking. This master's thesis does not involve correlations between the factors due to the time limit. The model would presumably give a better result if it were possible to take the interaction into account.

6.5.1 Questionnaire

The choice of using a questionnaire was determined by the time limit. The only possible way of making the weighting reflect as many experts as possible was by using a questionnaire. The valuation had probably been easier to the participants and more carefully done if the questionnaire only had included the ten valuation factors selected from the final selection. This was unfortunately not possible according to the time schedule. The questionnaire had to be sent out before the interviews were carried through.

6.6 Valuation and quantification

The simplest and most frequently used way of valuation is to valuate all factors with the same gauge and measurement units. The MADM methods make it possible to valuate factors with different measurement units. Unfortunately, the usability of the model reduces with differing gauge. The number of criteria, for the inspectors to remember, increases when each factor is to be valuated in its own way. Unfortunately, the objectivity may decrease when using the same measurement units. The criteria become more diffuse when the criterion is for example "adequate number of portable fire extinguisher …" instead of measure the exact number of extinguisher. The expression "adequate" stimulates subjective estimations. With the reason of meeting the usability demands the used measurement units are the same for all factors. In order to increase the objectivity, the criteria could be specified as much as possible without affecting the usability too much.

The objectivity is dependent on making the valuation based on the same criteria; otherwise the model will not give a comparable answer. According to the large number and shifting valuation

[13] Using the lower grading of the scale demanded one or more factors valued with 1, 2, 3 or 4.

assessors the obeying of the valuation criteria is of great importance to the objectivity of the result. If the valuation of the plants are done based on differing valuation criteria the relative LPP will loose its meaning and importance; consequently the result will be useless. The valuation maker's knowledge of existing and present criteria is consequently of extremely great importance.

One aspect of the valuation is that all plants are valued irrespective of type. The consequence of using the same criteria adjusted to all types of plants is that the model becomes general and overriding. The valuation factors importance to fire loss prevention is not always the same. There are several affecting aspects. The importance of automatic extinguishing system may not be the same for plants handling wet paper pulp as for plants handling fluff products. Different criteria assigned each type of plant would be to prefer but may not be practicable. The advantage of using the same criteria irrespective of type of plant is the usability. As mentioned before the number of criteria for the inspectors to remember should be kept low.

6.7 Scoring

The MADM models are widely used by decision makers within several subject areas. In this master's thesis the MADM model is used to produce a comparative and quantitative value to each plant.

Regarding to the fact that the WPM punishes low valued factors more strongly than the SAW method the WPM should be preferred. According to the analysis in chapter 4.9, showing only minimal difference, the best known and most widely used MADM method is chosen. The use of the WPM method will only lead to insignificantly deviations.

6.8 Uncertainties

Uncertainties are mostly derived from the usage of the model. The case study showed that the model intends to overestimate plants irrespectively of the quality of fire loss prevention. Consequently the model gives no room and possibility to reward further improvements. The overestimation is presumably derived from the valuation maker's usage of the criteria. The criteria examples are, with advantage, modified and revised after the first usage.

The scoring does nevertheless give a comfortably differentiation between the plants, even though the LPP model must be used with rationality and common sense.

It would have been preferably with a more extensive case study. The analysis would preferably include a larger number of valuation makers to compare their valuations and their usage of the criteria. It is important that the user of the model is aware that the model is not yet studied in use. An assessment is recommended after the first usage and a revision might be required.

7 Conclusions

Through this master's thesis a semi-quantitative method is developed, with attention to valuate and compare SCA plants relatively with reference to the quality of fire loss prevention work.

The model is practised within a case study at SCA. The case study showed that the model is able to provide SCA Risk managers with information, making it possible to distribute the premium with reference to fire loss prevention. There is no assessment included in the model, the LPP-model only valuates and compares plants relatively with reference to the quality of fire loss prevention work.

The identified questions with intention to fulfil the objective are accomplished through following procedures. The valuation factors are identified through literature studies, interviews and group meetings. The classification, quantification and contribution are made with reference to literature studies. The relation between the factors (the weighting) is received through a questionnaire, based on persons with experience. An example of a criteria guideline is given, in order to obtain objective input to the model. Through these procedures the objective is fulfilled.

The LPP-model does not replace all methodologically and logically thinking and must be used with rationality and common sense. Decision-making involves uncertainty and it is important that the decision makers are aware that the LPP-model only gives recommendations and no absolute answers.

Through the analysis several conclusions has been made. The LPP-model possesses/requires the following, qualities, potential improvements, limitations and fundamental prerequisites:

- The model is able to make a quantitative valuation and comparison between SCA plants with reference to fire loss prevention.
- The model is able to provide SCA Risk managers with information, making it possible to distribute the premium with reference to fire loss prevention.
- It is possible to add further factors to the LPP-model.
- The used method could with adjustments be appropriate to other companies or interested parties.
- The criteria examples could be modified, revised and increased to raise the objectivity of the model.
- The model would probably give a more accurate answer if interactions were taken into account.
- The model could preferable be adjusted to each type of plant, with modified models to different types of plant.
- The model is adopted and limited to SCA insurance company.
- The model is a quantification of the fire loss prevention work and will not include other factors as initial or residual risk or Estimated Maximum Loss.
- The model, especially the identification, weighting and valuation criteria, must always be updated and adjusted to the present preferences and FLP.
- The valuation assessors must be versed in fire loss prevention work and fully informed about the present FLP and valuation criteria.

Finally, SCA Risk Management division is recommended to define and clarify the Risk Management process used within SCA. The basic for successful loss prevention work is good Risk Management. Each phase within the Risk Management process must be defined starting with establishing the Risk Management context and developing a Risk Management strategy.

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Enclosure 1 – Potential valuation factors

Programmes and procedures

- Fire prevention
- Maintenance of existing plant facilities
- Self inspections
- Fire risk awareness – Training and education
- In-house Fire brigade – emergency team
- Public fire brigade
- Fire evacuation
- Housekeeping
- Impairment procedure
- Hot Work permit
- External contractors and visitors
- External inspections
- Documentation
- Incident reporting
- Smoking regulation
- Fire hazard analysis
- Emergency and Continuity plans

Buildings, machinery and fire protection equipment

- Fire separation
- Buildings and installations
    - Roof, walls, doors
    - Smoke/heat ventilation
    - Electrical installation (electrical rooms)
    - Lightning
    - Ventilation
    - Production equipment
    - Control and steering equipment
    - Access control
- Manual fire fighting
- Fire detection and alarm
    - Manual fire alarm
    - Automatic fire detection and alarm
- Automatic gas detection and alarm
- Automatic water sprinkler systems
- Fixed extinguishing system

Enclosure 2 – First selection

Processed and renamed factors
The expression fire prevention is used with a much wider extent than the definition used in this report. In this report fire prevention is defined as the “An proactive intention to prevent fires to occur”. Risk Management is a much more extensive expression and therefore Fire prevention will be exchanged for Risk Management.

Self-inspections and Maintenance of existing plant facilities are closely related to each other and therefore they will be valuated together and called Self-inspections and maintenance of existing plant facilities.

The control of visitors is relatively insignificant within SCA plants in Europe and therefore External contractors / visitors will be called Control of external contractors.

To clarify Buildings and installations it will be called Building construction. One important subchapter, Access control, were selected to be an independent factor and called Security and access control.

Fire detection and alarm comprise the subchapters, Manual fire alarm and Automatic fire detection and alarm. There is no reason to separate these two factors from each other with the reason that both are equally important to establish early warning and should be valued with the same weight. They will be valued together and called Fire detection and alarm.

To make it easy, both Automatic water sprinkler systems and Fixed extinguishing systems will be collected and valuated under the name Automatic extinguishing systems.

Dropped factors
External inspections are dropped because they are managed from the head office and not from the plants. The external inspections are consequently the same for all plants and make no difference to a premium distribution.

Documentation will be included in every concerned factor and therefore no need to be valued as a separate factor.

Enclosure 3 – Interview complication

Risk management

Needed.

It is important to implement risk management in the whole management system.

To measure the risk management level you could ask questions like "Is risk management discussed at the board meetings?" or look at records from board meetings.

It is interesting to know about the management's attitude and how thy follow-up questions about risk.

Risk management should be a part of the management system.

The management's attitude settles the loss prevention level.

There must be full support from the management and the attitude must be spread throughout the whole organisation, starting whit the management.

This is absolutely the most important factor to the fire loss prevention and must be taken into account when distribute premium.

The VD and vice VD must be involved in the process, show some involvement and appreciation of the fire loss prevention work.

This is one of the fundamental factors to the premium distribution.

Perhaps merge with Incident reporting and Fire hazard routines. They could be difficult to separate when value.

On which level is the risk management process based? Do the risk management questions attract attention on the right level? Are the questions supported from the management? These are questions to ask when value the risk management on plants.

Self inspection and maintenance of existing plant facilities

It is possible to merge self-inspection with housekeeping.

This is an important factor; keep it.

This is one of the fundamental factors to the premium distribution, very important.

This is absolutely a factor to affect the premium distribution.

Fire risk awareness – Training and education

This is a very, very important factor for the premium distribution. You should absolutely keep it even if it is difficult to valuate.

To valuate fire risk awareness you could look at the documentation of training and education.

This factor is important to get a successful result.

Implement the knowledge in the daily work.

To involve the personnel is important.

This factor is difficult to measure.

Housekeeping

Housekeeping is very important and possible to merge with self-inspection.

Should be taken account when distribute premium.

Should be taken into account when distribute premium.

This is one of the fundamental factors to the premium distribution.

This factor is difficult to measure; the personnel always clean up before inspection.

Smoking regulation

Smoking is no problem in Sweden but maybe in other countries.

This is an important factor but not to the premium distribution.

Too much regulation could lead to too much “smoke on the sly”.

This factor could be interesting at plant in Europe maybe not in Sweden.

Impairment procedure

You should keep the factor because lots of accidents happen when the sprinkler system is out of order.

The risk level is often increased at the same time as the prevention installation is out of service.

I suppose this factor will be considered without participation in the premium distribution. On the other hand, it is a very important factor because the importance of the sprinkler. The sprinkler protection system is one of the fundamental factors to the premium distribution and when the sprinkler system is out of service the safety level must be kept sufficient. This factor should be taken to account.

This factor is involved in the general risk management quality.

This factor’s existence I take for granted.

This is a compulsive factor to the paper industry.

Perhaps the factor is more important abroad.

Hot Work permits

Hot work permits are standard at all plants.

Hot work cases lots of damage and should therefore be taken into account when distribute premium.

This factor is involved in the general risk management quality.

This factor’s existence I take for granted.

This is a compulsive factor to the paper industry.

Perhaps the factor is more important abroad.

Control of external contractors

This factor is important but not to the premium distribution.

Difficult to measure.

This factor is involved in the general risk management quality.

This factor’s existence I take for granted.

This is a compulsive factor to the paper industry.

Perhaps the factor is more important abroad.

Incident reporting

It is important to fire loss prevention but I don’t know if the premium distribution has to be based on incident reporting.

This will be-all to get a successful process and should therefore be taken into account when distribute premium.

This factor should give the plant “better points” in the valuation.

Fire hazard analysis routine

A fire hazard analysis has to be carried out to identify the risks but I don't know if the premium distribution has to be based on the quality of the fire hazard analysis.

An important factor that put it all together.

This factor should give the plant "better points" in the valuation.

Security and access control

The security and access control is not important in Sweden but in other countries, to avoid arson.

Should be taken into account when distribute premium.

This factor's existence could perhaps be taken for granted.

This factor should be included in the premium distribution considering SCA's international plants.

Fire evacuation

It is important to save lives but you should not base the premium distribution on the quality of fire evacuation.

This is a very important factor but not to the premium distribution.

This isn't a premium distribution factor.

Emergency and Continuity plans

Prevention is number one and reduce or limit the losses is number two. Emergency and continuity plans are very important to limit economical losses. Should be included in the premium distribution model.

This is a very important factor especially to the consequential loss prevention. Should be taken into account when distribute premium.

These plans could reduce the losses whit several millions.

This factor should perhaps not be taken in account when distribute premium.

Public and in-house fire brigade

The emergency team and the in-house fire brigade should be valuated and included in the premium distribution model.

An emergency team or in-house fire brigade could do a fast fire fighting intervention before the public fire brigade is in place. They are familiar with the buildings and know the system.

An emergency team or in-house fire brigade do not need equipment equivalent to the public fire brigade.

Should not be taken into account when distribute premium.

Should not be taken into account when distribute premium.

Neither the public nor the in-house fire brigade will be in time to be able to perform an effective and successful fire fighting intervention.

Fire separation

Fire separation is very important to both fire loss prevention and premium distribution.

This is a very important instrument to the premium distribution.

Limit larger losses cased by fire spread between production and storage.

This factor should effect the premium distribution.

This factor's importance depends on the existence of automatic extinguishing system. You should be able to do a technical exchange without effecting the premium distribution. You could for example install sprinkler if the fire separation isn't enough.

Manual fire fighting equipment

Access to fire fighting equipment is important to an early extinguishing intervention.

It is much better to extinguish the fire in an early stage than wait for the public fire brigade.

This factor is important but not to premium distribution.

This factor’s existence I take for granted.

Could be useful to the premium distribution model.

Building construction

Building construction is important to the premium distribution. If the building is non-combustible the damage of the fire is limited and thereby the economical losses.

If the building is combustible the fire spread is reduced. A combustible building reduces the fire spread. The pressure becomes smaller and the strain on the fire separation walls reduces.

A non-combustible building causes a larger, slower and more complicated restoration. Restoration cost money.

The factor should effect the premium distribution even if a combustible building is very good from fire spread point of view.

Should affect the premium distribution but not too much.

Fire detection and alarm

Fire detection is very important, especially to the emergency team and the in-house fire brigade.

Fire detection and alarm make it possible for the emergency team or the in-house fire brigade to extinguish the fire in an early stage.

This factor is not important to the paper industry or to premium distribution. There should be detection when sprinkler is missing but when a fire is detected whit smoke or heat detection the fire is already to large to be extinguished.

This factor should give the plant “better points” in the valuation.

Automatic extinguishing systems

Automatic extinguishing systems are very important to the premium distribution. It has to be the right extinguish system at the right place otherwise the extinguish system has no effect.

This factor is extremely important to paper industry and to premium distribution. Every important building should be equipped with automatic sprinkler systems.

This is a very heavy decisive factor. This factor is very important to reduce fire and fire spread.

You shouldn’t trust the system too much and for that reason “Impairment procedure” becomes an important factor.

The extinguish systems is vulnerable to changed circumstances, for example other storage condition or application field. The dimension conditions are very important.

This is a very important factor to the premium distribution.

Factors possible to add

Estimated Maximum Loss (EML) could be of interest to premium distribution.

Perhaps a “collecting” factor to gather all factors missed out.

Electrical protection. There are lots of high voltage power stations at the plants within SCA. Over heated cables is a fire hazard.

Maybe add a factor to regard the explosion risk without fire occurrence. For example explosion in soda tanks.

Could be interesting to include storms, electrical risks and other risks without fire occurrence.

The fire load is often important to premium distribution within other insurance companies.

Other comments

Physical factors as sprinkler, alarm and fire brigades are easier to measure and thereby easier to include in the premium distribution.

There are correlations between the factors. A fire wall without a fire brigade doesn’t work.

Several plants in Europe have not sufficient water supply for fire fighting. That’s maybe something to consider when distribute premium.

Every factor is important but some would perhaps be easier to value merged.

What exactly do you mean with fire loss prevention?

Enclosure 4 – Questionnaire

Study of different factors importance to Fire Loss Prevention

My name is Therés Möller. I am studying Fire Engineering and Risk Management at the Department of Fire Safety Engineering, Lund University, Sweden. I am performing a thesis in order to achieve a Master of Science degree in Risk Management and Safety Engineering and a Bachelor of Science degree in Fire Protection Engineering.

The objective with the master's thesis is to suggest a model for quantitative valuation and comparison between SCA plants, with reference to fire loss prevention work. The thesis is performed by request of the SCA Insurance Company.

The work started with identifying factors appropriate for premium distribution within SCA. The identification was made in accordance with the SCA Risk Management Department in Stockholm and Munich.

In order to assign the factors individual weight, the factors importance to fire loss prevention is analysed. The analysis is based upon a questionnaire handed out to 28 randomly selected persons related to SCA. Some of those persons were also interviewed in order to validate the questionnaire and the identification of the factors. Those persons were selected in consultation with the SCA Risk Management Department in Stockholm.

Enclosed you will find the questionnaire containing the factors, which are to be analysed. It is important that you read through all the factors before you start filling out the questionnaire. I would like you to compare the factors to each other and then identify their importance to fire loss prevention. The questionnaire aims to decide which factors those are more or less important. The alternatives are from 1-10 where 10 represent "extremely important" and 0 represent the opposite "not important at all". Observe that different factors may be of the same importance to fire loss prevention, i.e. all factors could be "extremely important" to fire loss prevention. Mark your choices with an X.

The results of the questionnaire and the valuation model approach will be presented in a report during spring 2006. In the report your personal answers and opinions will not be identified. The report will be provided to persons participating in the study.

If you have any questions concerning the questionnaire you are welcome to contact me.

Therés Möller	Contact SCA:
+46 8 788 52 84	Per Larsson
theres.moller@sca.com	+46 8 788 53 39

Finally I would like you to return the questionnaire by mail, post or fax, as soon as possible, nevertheless at the latest **2005-11-07**.

Fax: **+468-7885306**

Yours sincerely!

Therés Möller

Background information

Age _________

Sex Male □ Female □

Occupation____

Former experiences in fire loss prevention work____

Experiences in fire loss prevention	< 1 year	1-5 years	➢ 6 year
	□	□	□

How important are these factors to Fire Loss Prevention?

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Impairment procedures An impairment procedure aims to makes sure the safety level remains sufficient when a sprinkler system or any other vital fire loss prevention installation is out of service.	□	□	□	□	□	□	□	□	□	□	□	□
Hot Work permits Hot work permits is meant to prevent fire incidents. For example routines, education, guidelines and rules.	□	□	□	□	□	□	□	□	□	□	□	□
Fire separation Fire separation within and between buildings aims to limit the onesquences of damage in case of a fire.	□	□	□	□	□	□	□	□	□	□	□	□

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Manual fire fighting equipment The equipment aims to makes it possible for the employees to extinguish a fire in an early stage.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Fire detection and alarm Fire detection and alarm aims to receive an early warning with a view to evacuate, manual fire fighting and immediately inform nearest fire brigade.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Automatic extinguishing system An automatic extinguishing system aims to put out the fire in an early stage or at least reduce the fire and limit the fire spread.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Risk Management Risk management is composed of several coordinated activities to direct and control an organization with regard to risk. One important factor is the management's attitude and interest in risk management matters.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Self inspections and maintenance of existing plant facilities Regular self-inspections aims to check and make sure the fire hazards are kept on a low level and all protection systems are in good working condition and maintained.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

	0	1	2	3	4	5	6	7	8	9	10	I don't know
Security and access control												

Security and access control aims at reduce the risk of arson by preventing unauthorized persons to enter the site unattended. For example fences, floodlights, irregular watch guard in-spections, etc.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Public and in-house fire brigade	0	1	2	3	4	5	6	7	8	9	10	I don't know
The public and in-house fire brigade aims to increase the chances of a fast and effective fire fighting intervention with a view to save lives and keep the business continuity alive.	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Enclosure 5 – Weighting and ranking

The points from the questionnaire were calibrated with reference to the mean value. Example is given for one person and one calibration. The used numbers are encircled.

$$\frac{10}{88} \cdot 83{,}9 = 9{,}5$$

Uncalibrated points from the questionnaire

Factor (nr)	1	2	3	4	5	6	7	8	9	10	Sum:
	10	10	9	8	9	10	8	9	8	7	**88**
	9	10	9	9	9	9	9	10	9	6	89
	9	10	9	9	8	5	8	7	6	6	77
	9	7	9	5	7	6	9	5	6	5	68
	10	10	10	10	10	6	10	9	8	8	91
	10	10	10	8	10	9	10	10	8	5	90
	10	10	10	10	8	7	9	5	8	8	85
	10	6	3	3	3	5	3	5	7	2	47
	10	8	7	7	7	8	9	7	8	7	78
	10	8	8	10	8	10	8	8	10	6	86
	8	9	10	10	10	9	7	8	8	9	88
	8	10	9	10	10	10	4	10	8	4	83
	10	8	9	9	8	8	8	7	8	7	82
	10	9	10	10	9	10	10	7	9	8	92
	10	10	10	8	9	9	8	7	9	7	87
	10	10	8	9	10	10	7	8	9	9	90
	9	5	10	10	10	10	8	6	7	8	83
	10	10	10	10	10	10	2	7	6	5	80
	8	9	10	10	9	8	8	10	8	9	89
	10	8	8	10	10	8	8	8	8	8	86
	10	10	10	10	8	9	9	10	9	7	92
	9	9	8	10	8	8	10	10	7	7	86
	9	10	8	10	9	9	10	5	8	7	85
	9	8	9	9	10	9	8	8	9	6	85
	10	9	10	9	9	8	7	8	8	8	86
	10	10	7	6	10	10	10	10	8	7	88
Sum:	247,0	233,0	230,0	229,0	228,0	220,0	207,0	204,0	207,0	176,0	Total sum: 2181
											Average: **83,9**

Calibrated points

Factor (nr)	1	2	3	4	5	6	7	8	9	10
	9,5	9,5	8,6	7,6	8,6	9,5	7,6	7,6	8,6	6,7
	8,5	9,4	8,5	8,5	8,5	8,5	8,5	8,5	9,4	5,7
	9,8	10,9	9,8	9,8	8,7	5,4	6,5	8,7	7,6	6,5
	11,1	8,6	11,1	6,2	8,6	7,4	7,4	11,1	6,2	6,2
	9,2	9,2	9,2	9,2	9,2	5,5	7,4	9,2	8,3	7,4
	9,3	9,3	9,3	7,5	9,3	8,4	7,5	9,3	9,3	4,7
	9,9	9,9	9,9	9,9	7,9	6,9	7,9	8,9	4,9	7,9
	17,8	10,7	5,4	5,4	5,4	8,9	12,5	5,4	8,9	3,6
	10,8	8,6	7,5	7,5	7,5	8,6	8,6	9,7	7,5	7,5
	9,8	7,8	7,8	9,8	7,8	9,8	9,8	7,8	7,8	5,9
	7,6	8,6	9,5	9,5	9,5	8,6	7,6	6,7	7,6	8,6
	8,1	10,1	9,1	10,1	10,1	10,1	8,1	4,0	10,1	4,0
	10,2	8,2	9,2	9,2	8,2	8,2	8,2	8,2	7,2	7,2
	9,1	8,2	9,1	9,1	8,2	9,1	8,2	9,1	6,4	7,3
	9,6	9,6	9,6	7,7	8,7	8,7	8,7	7,7	6,7	6,7
	9,3	9,3	7,5	8,4	9,3	9,3	8,4	6,5	7,5	8,4
	9,1	5,1	10,1	10,1	10,1	10,1	7,1	8,1	6,1	8,1
	10,5	10,5	10,5	10,5	10,5	10,5	6,3	2,1	7,3	5,2
	7,5	8,5	9,4	9,4	8,5	7,5	7,5	7,5	9,4	8,5
	9,8	7,8	7,8	9,8	9,8	7,8	7,8	7,8	7,8	7,8
	9,1	9,1	9,1	9,1	7,3	8,2	8,2	8,2	9,1	6,4
	8,8	8,8	7,8	9,8	7,8	7,8	6,8	9,8	9,8	6,8
	8,9	9,9	7,9	9,9	8,9	8,9	7,9	9,9	4,9	6,9
	8,9	7,9	8,9	8,9	9,9	8,9	8,9	7,9	7,9	5,9
	9,8	8,8	9,8	8,8	8,8	7,8	7,8	6,8	7,8	7,8
	9,5	9,5	6,7	5,7	9,5	9,5	7,6	9,5	9,5	6,7
Sum:	251,5	233,8	229,1	227,2	226,5	220,0	208,7	206,0	203,8	174,3

Significant difference

It is possible to ensure significant difference through an estimation of the confidence interval for the mean of the factors difference (Körner & Wahlgren, 2002). Following formula was used attempting to ensure a difference between the valuation factors:

$$\frac{1}{n}\sum d \pm z\left(\frac{s}{\sqrt{n}}\right),$$

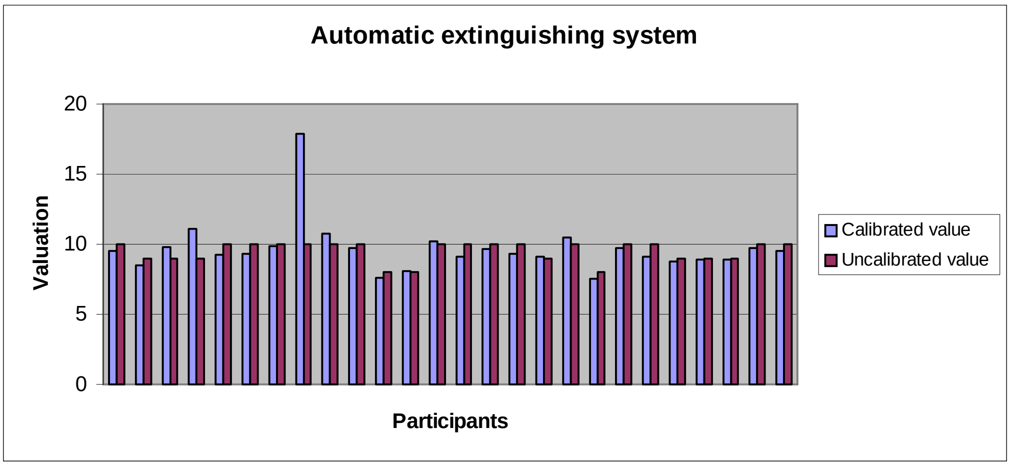
where	d	difference between each person’s answer to factor j and j+1
	z	1,96 to 95 % confidence level
	s	standard deviation of d
	n	size of sample

The formula is limited to, large enough, normal distributed samples. If the confidence interval for the mean of the factors difference includes the number zero the two factors are not significantly different (Körner & Whalgren, 2002).

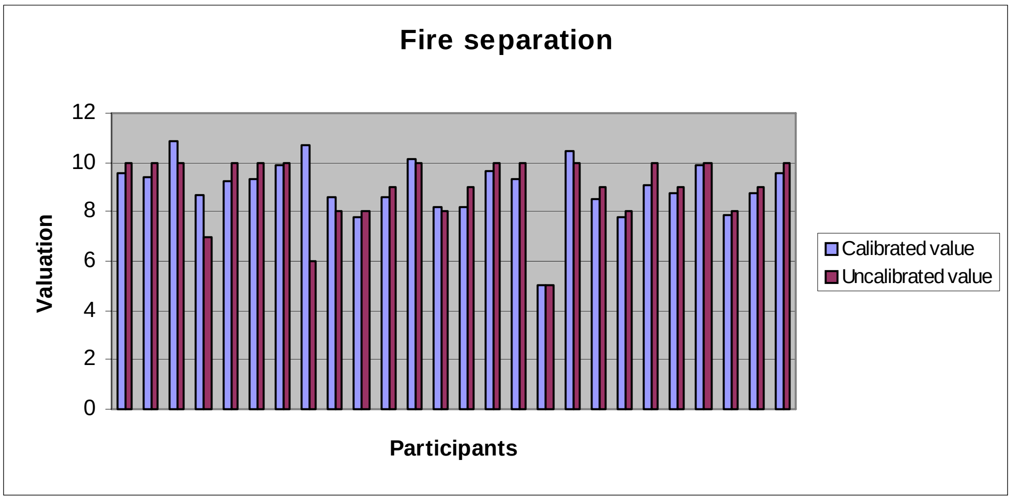
Compared factors	Confidence interval	Significant difference ensured
Factor 1 / Factor 2	0,68 ± 0,73	No
Factor 2 / Factor 3	0,18 ± 0,72	No
Factor 3 / Factor 4	0,07 ± 0,55	No
Factor 4 / Factor 5	0,03 ± 0,53	No
Factor 5 / Factor 6	0,25 ± 0,56	No
Factor 6 / Factor 7	0,43 ± 0,58	No
Factor 7 / Factor 8	0,10 ± 0,91	No
Factor 8 / Factor 9	0,09 ± 1,0	No
Factor 9 / Factor 10	1,13 ± 0,88	Yes

The valuation factors could not be guaranteed significantly different with this formula. The reason of this is the contracted distribution from the questionnaire. The whole scale 1-10 was not used by everyone. The most frequently used valuation is 10, which represent the calibrated value of 9 to10. There are a few persons who have used the whole scale, which represent the high-calibrated scores.

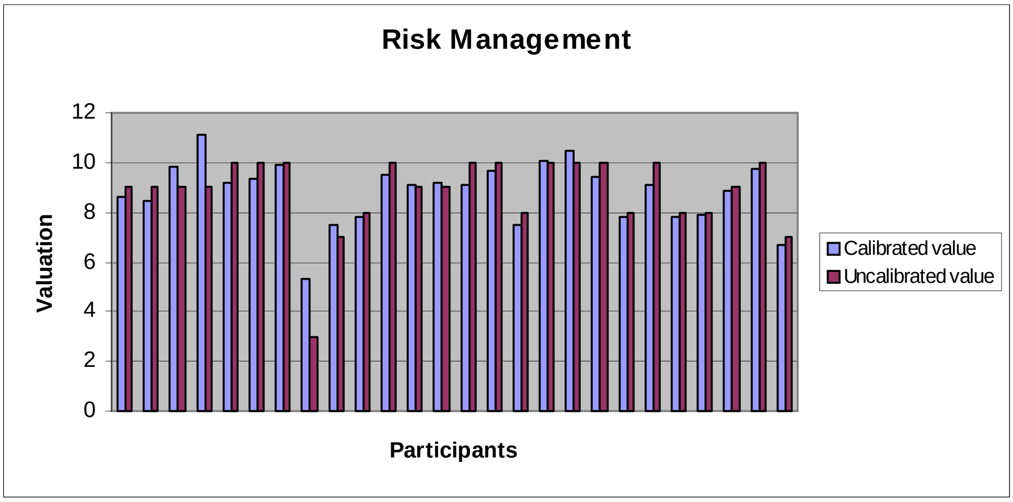
Weighting of the valuation factors
Each valuation factors calibrated values are here documented and compared to the factors uncalibrated values.



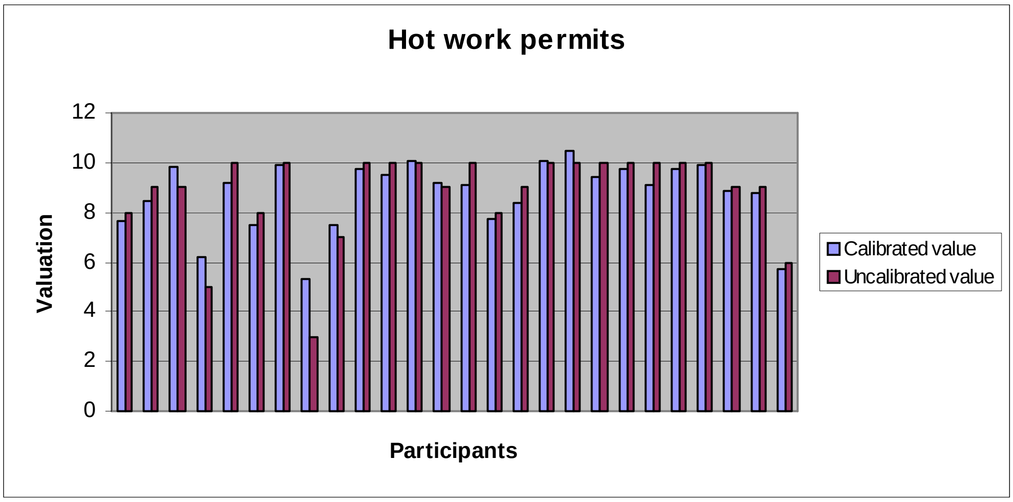
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	270,7	247,0	Median	9,4	10
Weight	**0,115**	**0,113**	Variance	3,5	0,5
Average	9,7	9,5	Standard deviation	1,8	0,7
Average > 50 year	9,4	9,5	95 % confidence interval	0,7	0,3
Average < 51 year	9,8	9,7			



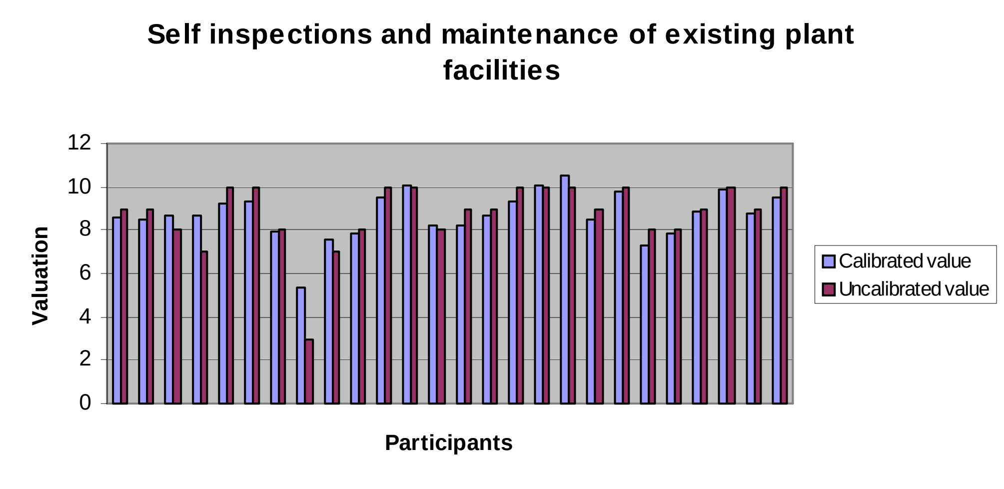
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	233,8	233,0	Median	9,2	9,5
Weight	**0,107**	**0,107**	Variance	1,4	1,9
Average	9,0	9,0	Standard deviation	1,2	1,4
Average > 50 year	8,6	9,0	95 % confidence interval	0,5	0,5
Average < 51 year	9,1	8,8			



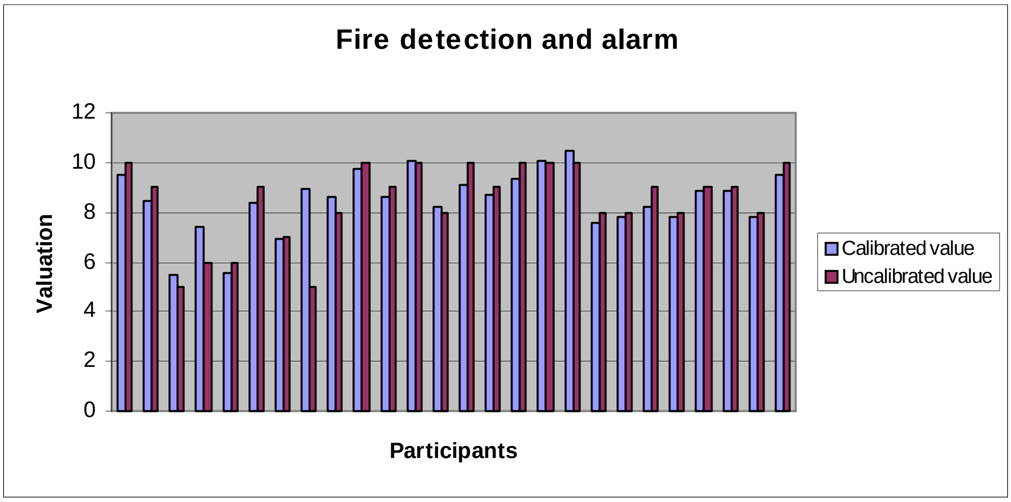
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	229,1	230,0	Median	9,1	9,0
Weight	**0,105**	**0,105**	Variance	1,6	2,4
Average	8,8	8,8	Standard deviation	1,3	1,5
Average > 50 year	9,1	8,7	95 % confidence interval	0,5	0,6
Average < 51 year	8,7	9,3			



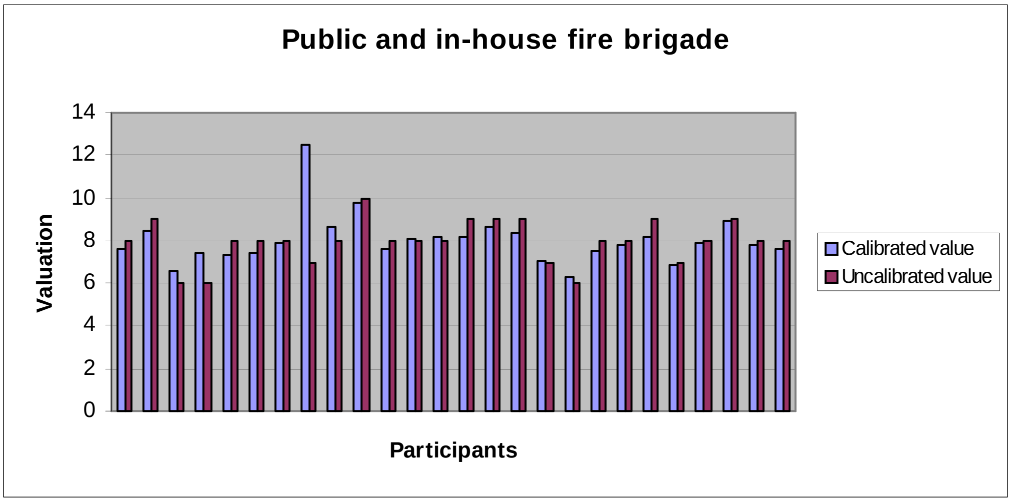
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	227,2	229,0	Median	9,2	9,5
Weight	**0,104**	**0,105**	Variance	1,9	3,2
Average	8,7	8,8	Standard deviation	1,4	1,8
Average > 50 year	8,6	8,8	95 % confidence interval	0,5	0,7
Average < 51 year	8,8	8,8			



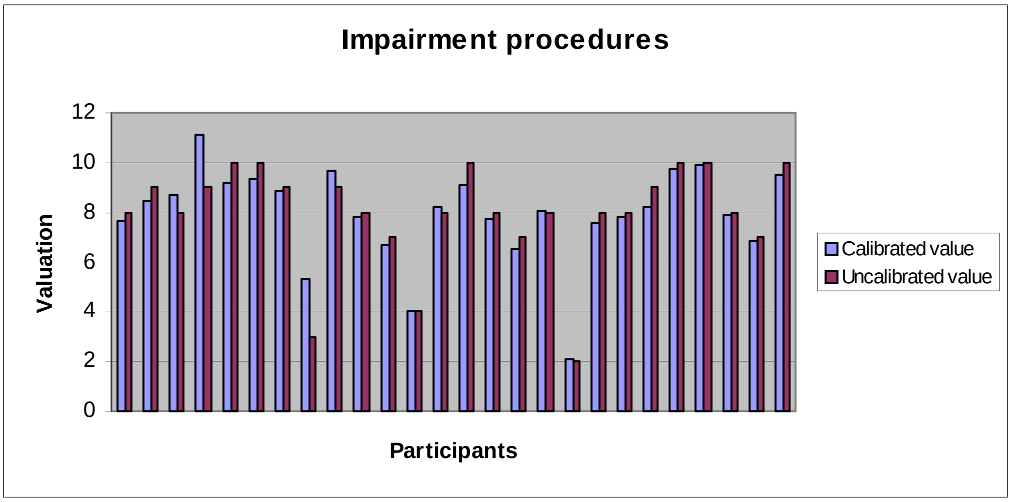
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	226,5	228,0	Median	8,7	9,0
Weight	**0,104**	**0,105**	Variance	1,2	2,3
Average	8,7	8,8	Standard deviation	1,1	1,5
Average > 50 year	9,4	8,5	95 % confidence interval	0,4	0,6
Average < 51 year	8,5	9,7			



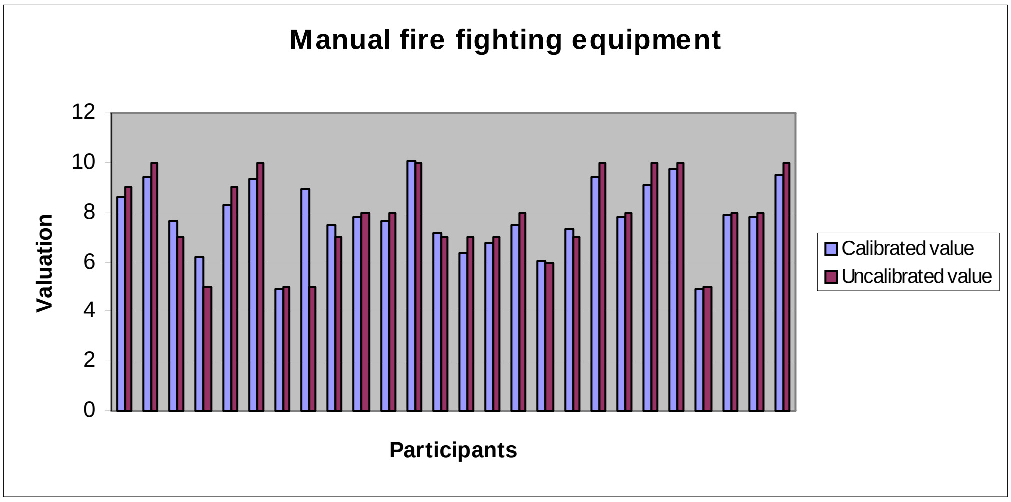
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	220,0	220,0	Median	8,6	9,0
Weight	**0,101**	**0,101**	Variance	1,6	2,4
Average	8,5	8,5	Standard deviation	1,2	1,6
Average > 50 year	9,3	8,2	95 % confidence interval	0,5	0,6
Average < 51 year	8,2	9,5			



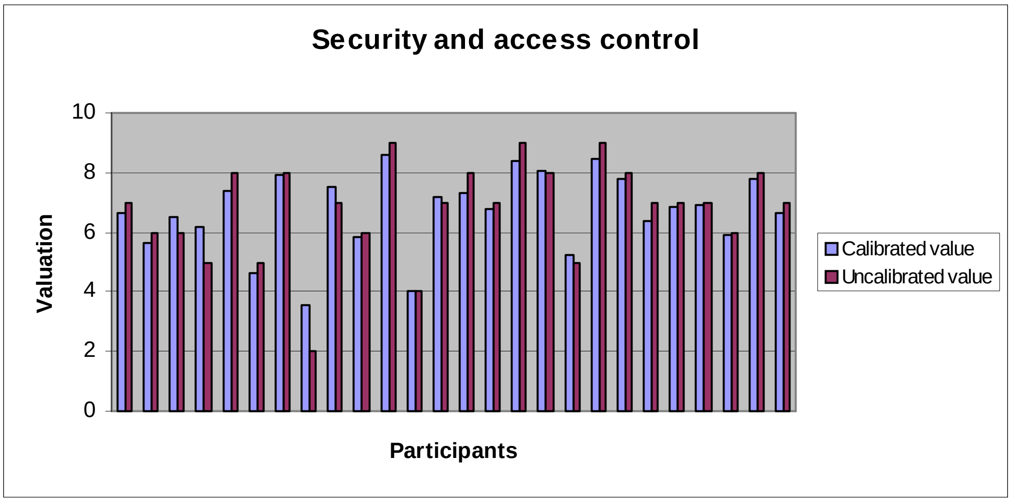
	Calibrated value	Mean value		Calibrated value	Mean value
Sum	208,7	207,0	Median	8,0	8,0
Weight	**0,096**	**0,095**	Variance	1,0	1,0
Average	8,0	8,0	Standard deviation	1,0	1,0
Average > 50 year	7,6	8,0	95 % confidence interval	0,4	0,4
Average < 51 year	8,2	7,8			



	Calibrated value	Mean value		Calibrated value	Mean value
Sum	206,0	207,0	Median	8,0	8,0
Weight	**0,094**	**0,095**	Variance	4,4	1,0
Average	7,9	8,0	Standard deviation	2,1	1,0
Average > 50 year	7,5	8,0	95 % confidence interval	0,8	0,4
Average < 51 year	8,0	7,8			



	Calibrated value	Mean value		Calibrated value	Mean value
Sum	203,8	204,0	Median	7,8	8,0
Weight	**0,093**	**0,094**	Variance	2,0	3,0
Average	7,8	7,8	Standard deviation	1,4	1,7
Average > 50 year	8,2	7,7	95 % confidence interval	0,5	0,7
Average < 51 year	7,7	8,5			



	Calibrated value	Mean value		Calibrated value	Mean value
Sum	174,3	176,0	Median	7,8	7,0
Weight	**0,080**	**0,081**	Variance	2,0	2,7
Average	6,7	6,8	Standard deviation	1,4	1,6
Average > 50 year	6,2	6,9	95 % confidence interval	0,5	0,6
Average < 51 year	6,9	6,3			

Enclosure 6 – The WPM method vs. The SAW method

	Factor 1		Factor 2		Factor 3		Factor 4		Factor 5		Factor 6		Factor 7		Factor 8		Factor 9		Factor 10	
Valuation (v_{ij}) Weight (w_j)	(v_{i1})	(w_1)	(v_{i2})	(w_2)	(v_{i3})	(w_3)	(v_{i4})	(w_4)	(v_5)	(w_5)	(v_6)	(w_6)	(v_7)	(w_7)	(v_8)	(w_8)	(v_9)	(w_9)	(v_{10})	(w_{10})
Plant 1	4	w_1	4	w_2	4	w_3	4	w_4	4	w_3	4	w_6	4	w_7	4	w_8	4	w_9	4	w_{10}
Plant 2	3	w_1	3	w_2	3	w_3	3	w_4	3	w_3	3	w_6	3	w_7	3	w_8	3	w_9	3	w_{10}
Plant 3	2	w_1	2	w_2	2	w_3	2	w_4	2	w_3	2	w_6	2	w_7	2	w_8	2	w_9	2	w_{10}
Plant 4	1	w_1	1	w_2	1	w_3	1	w_4	1	w_3	1	w_6	1	w_7	1	w_8	1	w_9	1	w_{10}
Plant 5	4	w_1	3	w_2	4	w_3	3	w_4	4	w_3	3	w_6	4	w_7	3	w_8	4	w_9	3	w_{10}
Plant 6	3	w_1	4	w_2	3	w_3	4	w_4	3	w_3	4	w_6	3	w_7	4	w_8	3	w_9	4	w_{10}
Plant 7	3	w_1	2	w_2	3	w_3	2	w_4	3	w_3	2	w_6	3	w_7	2	w_8	3	w_9	2	w_{10}
Plant 8	2	w_1	3	w_2	2	w_3	3	w_4	2	w_3	3	w_6	2	w_7	3	w_8	2	w_9	3	w_{10}
Plant 9	2	w_1	1	w_2	2	w_3	1	w_4	2	w_3	1	w_6	2	w_7	1	w_8	2	w_9	1	w_{10}
Plant 10	1	w_1	2	w_2	1	w_3	2	w_4	1	w_3	2	w_6	1	w_7	2	w_8	1	w_9	2	w_{10}
Etc.																				

	Loss prevention point (LPP)	
Valuation (v_{ij}) Weight (w_j)	**WPM**	**SAW**
	$V(A_i) = \prod_{j=1}^{n} v_{ij}^{w_j}$	$V(A_i) = \sum_{j=1}^{n} w_j v_{ij}$
Plant 1	4,0 (Max)	4,0 (Max)
Plant 2	3,0	3,0
Plant 3	2,0	2,0
Plant 4	1,0 (Min)	1,0 (Min)
Plant 5	3,5	3,5
Plant 6	3,5	3,5
Plant 7	2,5	2,5
Plant 8	2,4	2,5
Plant 9	1,4	1,5
Plant 10	1,4	1,5
Etc.	…	…

Enclosure 7 – Sensitivity analysis

Received weighting and ranking

Post-risk options	Weighting (order of rank)	Pre-risk options	Weighting (order of rank)
Automatic extinguishing systems	0,113 (1)	Risk management	0,105 (3)
Fire separation	0,107 (2)	Hot work permits	0,105 (4)
Fire detection and alarm	0,101 (6)	Self inspections and maintenance of existing plant facilities	0,105 (5)
Manual fire fighting equipment	0,094 (8)	Impairment procedures	0,095 (7)
Public and in-house fire brigade	0,095 (7)	Security and access control	0,081 (9)
Sum:	0,509	Sum:	0,491

Calibrated weights

Post-risk options	Weighting (order of rank)	Pre-risk options	Weighting (order of rank)
Automatic extinguishing systems	0,115 (1)	Risk Management	0,105 (3)
Fire separation	0,107 (2)	Hot work permits	0,104 (4)
Fire detection and alarm	0,101 (6)	Self inspections and maintenance of existing plant facilities	0,103 (5)
Manual fire fighting equipment	0,094 (8)	Impairment procedures	0,096 (7)
Public and in-house fire brigade	0,093 (9)	Security and access control	0,080 (10)
Sum :	0,511	Sum :	0,489

The weightings support of post-risk options influence on the model result.

Valuation factors		Valuation	
Automatic extinguishing systems	Post- risk options	4	1
Fire separation		4	1
Fire detection and alarm		4	1
Manual fire fighting equipment		4	1
Public and in-house fire brigade		4	1
Risk Management	Pre- risk options	1	4
Hot work permits		1	4
Self inspections and maintenance of existing plant facilities		1	4
Impairment procedures		1	4
Security and access control		1	4
	LPP:	**2,53**	**2,47**

Enclosure 8 – Reality study

The reality study was carried through in order to examine the applicability of the LPP-model. The reality study included the valuation of two plants made by an experienced valuation maker. The valuation maker selected one plant with high quality risk treatment and one plant with sufficient risk treatment.

The valuation points received from the reality study were used as input to the LPP-model. Received LPP points were also used in SCA premium distribution model and the result was analysed in order to examine the usability of the LPP as input to the premium distribution model used within SCA.

Valuation factors	Weighting	**Valuation**	
		Plant 1	**Plant 2**
Automatic extinguishing systems	0,115	2	4
Fire separation	0,107	4	4
Risk Management	0,105	2	4
Hot work permits	0,104	2	4
Self inspections and maintenance of existing plant facilities	0,103	2	4
Fire detection and alarm	0,101	3	4
Impairment procedures	0,096	3	4
Manual fire fighting equipment	0,094	2	3
Public and in-house fire brigade	0,093	3	4
Security and access control	0,080	4	4
	Model result:	2,7	3,9

Plant 1 is a plant with sufficient Risk Management and poorly performed Loss prevention. The importance of Fire loss prevention is not made clear.

Plant 2 is one of the most prominent plants within SCA, with reference to Fire loss prevention. The Fire loss prevention is top performed but continuous improvements are not completely ensured.

The LPP model intends to score the plants highly irrespectively of the quality of Fire loss prevention. Consequently the model gives no room and possibility to reward further improvements. The most probable explanation to the high valuation is that the criteria is not correctly used or not followed. The incorrect usage could be attributable to indistinct or unclear criteria, or badly chosen valuation levels.

If the valuation level 1 never is used and level 4 is used frequently, the criteria examples must be modified in order to represent the risk treatment level within SCA. If the LPP model continuous to give results near 4,0 a modification and adjustment of the valuation levels is to be considered.

Enclosure 9 – Selected valuation factors with criteria examples

Automatic extinguishing systems

Very good

All automatic extinguish systems follows all requirements in SCA Fire Loss Prevention Requirements and recommendations.

All automatic extinguisher systems are regularly tested and maintained.

The protection is more than equivalent to the risk of fire. All high-risk areas are equipped with suitable automatic extinguish system.

Good

At least all production and storage buildings are equipped with suitable automatic extinguish system.

All water sprinkler systems are following the European CEA 4001 code or the US NFPA code. The system has an alarm connection to the public fire brigade or to a permanently manned central station. There are at least two pumps installed. If there is a reliable enough (also during a fire) source of power one pump can be electrically driven, otherwise both must be diesel driven.

Every other form of fixed extinguisher system is discussed with and approved by SCA Risk Management Department before installation.

All hydraulic oil systems are protected with automatic foam sprinkler system.

Manual water sprinkler are installed where automatic water sprinkler is not suitable.

Any specific machine line, with a high fire load and/or of vital importance and where a fast spread of glowing materials/fire is foreseen, is protected with suitable automatic extinguishing installations. The rooms for the equipment are, as well, fully equipped with automatic extinguishing system on all levels and in all areas, including hood and basement.

Dust creating filters and rooms are equipped with, quick responding, specially designed automatic extinguishing systems.

Fair

Almost every production and storage building is equipped with suitable automatic extinguish system.

Sprinkler installations follow a domestic Code.

Poor

The automatic extinguish system is insufficient and defective.

Fire separation

Very good

The fire separation follows all requirements and recommendations in SCA Fire Loss Prevention Requirements.

Effective policies and programmes are implemented at concerned level of the organisation to make sure the fire separation quality is kept on a generally approved level.

Good

There are some insignificant deviations from the valuation level Very good but the most important recommendations are followed.

All penetrations through any REI wall are avoided or properly fire protected with the same fire separation quality as the wall.

All doors and openings are equipped with automatic closing device or always kept closed.

Complied recommendations are at least following:

Between production and storage areas with high fire load the partitioning walls are at least class REI 240 minutes.

Between production areas the partitioning walls are at least class REI 120 minutes.

All other separations are at least EI 60 – 120 minutes and this is valid for following areas;

- Storage for models, vital spare parts, etc
- Electrical rooms / Charging of batteries
- Boilers
- Transformers
- Oil/Chemical storage
- Dust collecting filters
- Waste bailers
- Workshops
- Laboratories
- Other areas with high ignition or specific content risk
- Offices

All openings in these walls have automatically operated door or shutters with the same fire separation quality as the wall.

Fair

Requirements followed in SCA Fire Loss Prevention Requirements are at least:

Between production and storage areas with high fire load the partitioning walls are at least class REI 240 minutes.

Between major production areas the partitioning walls are at least class REI 120 minutes.

Poor

The separations within the plant deviate from the criteria mentioned in “Fair”.

Risk Management

Very good

The approach to Risk Management is adopted at the highest level and implemented at all functional levels; Risk Management is integrated into the culture of the organization.

Each employee view Risk Management as a part of his or her job despite the differences in the responsibilities activities and nature of the risk at each level.

All steps in the Risk Management process is carried through and repeated continuously within the entire organization.

The process is flexible and iterative, continuous and developing and thereby improves continuously.

Good

The Risk Management strategy is translated into tactical and operational objectives.

Managers view Risk Management as an integral part of their job. The assignment of responsibility within the managers is clear.

Fair

The Risk Management process and its context are in an establishing stage.

The assignment of responsibility is defective.

Poor

Key activities, processes and instruments such as risk identification and analysis are under identification and/or development.

Hot Work permits

Very good

Hot work permits follow all requirements and recommendations in SCA Fire Loss Prevention Requirements.

Hot work permits are issued for any individual job on a daily basis. The policy and the rules are implemented into the culture of the organisation and strictly followed for all kinds of works, where there is a risk for an ignition.

Good

A proper routine for hot work permits and arrangements exists.

Hot work permits are valid for all hot works carried out by both internal and external personal.

Fair

Permits are only valid for external contractors or not strictly followed.

Poor

Hot work permits and arrangements are insufficient and defective.

Self inspection and maintenance of existing plant facilities

Very good

The self-inspection and maintenance follows all requirements and recommendations in SCA Fire Loss Prevention Requirements.

Self-inspections and maintenance of existing plant facilities has become a part of the working culture.

Good

The scope and frequency of self-inspections are determined together with the Approved SCA Risk Engineer and the public fire brigade. Maximum interval between inspections is however one month for all items on the checklist.

There are established checklists and routines used to direct and document the self-inspections and maintenance of plant facilities. The checklist includes at least every essential valuation factor and further:

- Chemicals and flammable gases and liquids
- Smoking areas
- Electrical installations
- Housekeeping
- Storage

There is a formal system for attending the remarks and deficiencies that internal and external inspections identify. Deficiencies and malfunctions are attended to without delay.

Fair

Self-inspections and maintenance takes place occasionally or the interval between inspections is more than one month.

Poor

There are no self-inspections undertaken within site.

Fire detection and alarm

Very good

All fire detection and alarm systems follow all requirements in SCA Fire Loss Prevention Requirements and recommendations.

Effective policies and programmes are implemented at concerned level of the organisation to make sure the quality of the fire detection and alarm systems always are kept on generally approved levels.

Good

Manual fire alarm is, at minimum, emergency telephones and push button fire alarm system in areas where early warning is important for evacuation alarm purpose.

All indoor (and outdoor, when suitable) areas are protected with an appropriate detection system. Smoke detection is mainly used; heat detection is only used where smoke detectors are not suitable due to a dusty or smoky environment.

The fire alarm signal is sent to the public fire brigade or to another permanently manned station.

Any production equipment is, when necessary, provided with overheating detection.

Any specific machine line, with a high fire load and/or of vital importance and where a fast spread of glowing materials/fire is foreseen, is protected with suitable automatic infrared detection.

Battery-charging areas for more than tree batteries are equipped with automatic fire detection system.

Fair

Manual fire alarm is, at minimum, emergency telephones and push button fire alarm system in areas where early warning is important for evacuation alarm purpose.

Only some areas are protected with an appropriate detection system.

Poor

The manual fire alarm or the automatic detection system is insufficient and defective.

Public and in-house fire brigade

Very good

The nearest full time brigade is situated in a close distance and the response time[14] is maximum 10 minutes or, the plant has an equivalent in-house fire brigade, fully equipped and well educated with response time maximum 10 minutes

The plant has developed a close co-operative relationship with the fire brigade in order to make best use of their competence.

The fire brigade is familiar with the fire hazards, the layout of the plant, the evacuation routines, the water supply and the fire protection systems.

The fire brigade is regularly informed on the changes in the plant, the plant evacuation procedures and is always invited to participate in training sessions with the In-house fire brigade / emergency team and in the regular fire evacuation drills.

Good

The nearest full time brigade is situated in a close distance and the response time is maximum 15 minutes or the plant has a fully equipped and well-educated in-house fire brigade.

The fire brigade is familiar with the fire hazards, the layout of the plant, the evacuation routines, the water supply and the fire protection systems.

Fair

The nearest fire brigade is situated in a close distance and the response time is maximum 20 minutes or the plant has an educated in-house fire brigade.

Poor

The nearest brigade response time is more than 20 minutes or the plant deviates from the criteria mentioned in “Fair”.

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[14] Response time is within SCA defined as the time interval between the fire brigade’s receipt of the alarm and the fire brigade’s arrival at the present location.

Impairment procedure

Very good

The impairment procedure follows all requirements and recommendations in SCA Fire Loss Prevention Requirements.

Effective policies and programmes are implemented at concerned level of the organisation to make sure the impairment procedures are kept on a generally approved level.

Good

A proper impairment procedure exists including a test of the system after the correction, how to inform internally and externally.

The public fire brigade and SCA Approved Fire Engineer are always notified.

Fair

Impairment procedures are practised occasionally.

The public fire brigade is always notified.

Poor

The impairment procedure is significant defective or missing.

Manual fire fighting equipment

Very good

The manual fire fighting equipment follows all requirements and recommendations in SCA Fire Loss Prevention Requirements.

Effective policies and programmes are implemented at concerned level of the organisation to make sure the quality of the manual fire fighting equipment always is kept on a generally approved level.

Good

Water supply

Enough capacity and pressure to meet the combined demand of the automatic sprinkler system and the standpipe, hydrant and hose reel systems.

Tested and documented annually to ensure the water sources are sufficient for fire fighting at all times.

Portable fire extinguisher

Adequate number, type and size.

Located and well marked at strategic places throughout the plant.

Maximum walking distance is 50 meters.

Always easily accessed and never blocked, especially important at equipment of importance and places with high fire load.

Hose reels

The fire hose reel system cover all areas of the plant.

Always easily accessed and never blocked, especially important at equipment of importance and at places with high fire load.

Hydrants

The capacity and dimension of the hydrants are in relation to the fire load. They are clearly marked and always easily accessed.

Fair

Portable fire extinguisher

Adequate type and size

Located at various strategic places throughout the plant.

Maximum walking distance is 50 meters.

Always easily accessed and never blocked, especially important at equipment of importance and places with high fire load.

Hose reels

The fire hose reel system cover all areas of the plant.

Always easily accessed and never blocked, especially important at equipment of importance and at places with high fire load.

Poor

The manual fire fighting equipment is considered poor.

Security and access control

Very good

The security and access control follows all requirements and recommendations in SCA Fire Loss Prevention Requirements.

Effective policies and programmes are implemented at concerned level of the organisation to make sure the security and access control is kept on a generally approved level.

Good

The site is fenced in, alarmed and floodlights exist when needed.

Security guards make irregular inspection rounds during non-working hours and in unmanned areas.

Fair

The site is fenced in and the premises are locked.

Security guards make inspections rounds.

Poor

The site is poorly secured.

Enclosure 10 – Other significant features

One factor that was mentioned at the interviews was "Other significant features". The factor aim to make it possible to value factors missed out through the identification. Unfortunately this factor was not weighted together with the other factors and therefore not possible to use in this model. The factor could be included in the model with the next model revision. A suggestion of explanation and assigned criteria are as follow:

Other significant features

The plant is in one way or the other equipped with a risk treatment option not included in the valuation model. This risk treatment options is meant to be valued here.

Very good

The valuation of the risk treatment option matches criteria to valuation level Very good objecting a comparable valuation factor.

Good

The valuation of the risk treatment option matches criteria to valuation level Good objecting a comparable valuation factor.

Fair

The valuation of the risk treatment option matches criteria to valuation level Fair objecting a comparable valuation factor.

Poor

The valuation of the risk treatment option matches criteria to valuation level Poor objecting a comparable valuation facto