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DEVELOPING A PROACTIVE SAFETY PERFORMANCE MEASUREMENT TOOL (SPMT) FOR CONSTRUCTION SITES

by

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'Safety pays' is a phrase commonly used but when it comes to putting the concept into practice, very few are actually successful at it. Excuses made include that it is costly or it is a waste of time or it is not the main cause of failure. However, the real problem is that there is not enough guidance on how to improve safety performance on site. Traditional measurement approaches include accident investigations, inspections and job safety analyses. The question often posed is do these statistics reflect the actual safety effectiveness on site? Almost always they do not. These numbers often just tell how lucky or unlucky the site has been and do not reflect the level of effectiveness of safety performance on site. The key question is if this reactive, backward looking approach does not portray the true picture, what is the best approach?

What the industry needs is a new paradigm for measuring safety performance on construction sites i.e. a proactive approach rather than just depending on the reactive data. Studies by many researchers have suggested moving away from these post-accident scenarios towards a proactive approach that measures site activities and safe behaviour rather than unsafe behaviour. The proactive approach is able to provide essential feedback on performance before incidents occur. These on-going measures are able to monitor the safety performance on site. Various in-house systems exist but the industry lacks a comprehensive tool that can be used on any site.

In response to this need, the objectives of this research were the:

- identification of the important proactive safety control measures (SCMs) and indicators of safety performance for construction sites;
- development of a safety performance measurement tool (SPMT); and
- validation of SPMT through implementation on case study sites.

The safety performance measurement tool (SPMT) has been designed as an interactive assessment tool using MS Access and MS Excel to measure safety performance for construction sites. SPMT uses available knowledge to generate a solution to an industry safety problem. This tool concentrates on proactive measures of culture and behaviour. It is applied on site using questionnaires, observations and document checks, which are entered into a measurement database. SPMT has been designed to include the participation of head office management, site management, site supervisors, site operatives and specialist-contractor's management. The tool has been developed from an extensive literature review and three incremental surveys using expert opinion and a broader verification from a large industry sample. SPMT has been validated through field tests on four construction projects, with two projects including a further application after responding to feedback from the first test.

SPMT enables real-time feedback on safety performance, identifies substandard performance, allows focussed remedial action and evaluates the progress or regress of safety performance on construction sites. The future potential of SPMT as a generic safety performance measurement tool has been demonstrated.

SPMT aims to move the industry away from a purely reactive response and towards a more proactive approach to the improvement of safety performance. This approach will contribute to changing the working culture in the construction industry.

In addition to producing SPMT this work also established the following overall conclusions:

1. there is a need to enhance the safety culture in the construction industry;
2. the construction industry still measures safety performance against accident statistics even though they may adopt a proactive approach;
3. there is a critical need for a proactive safety measurement tool for the construction industry;
4. there is a need to involve all categories of personnel in safety performance assessment;
5. the methods adopted to carry out the performance should be generic and comprehensive; and,

6. feedback of results of assessment should be informative, able to convey areas of weakness, and able to inform remedial actions.

This research has also contributed to safety performance research by addressing a number of underlying factors including:

1. the establishment of thirty safety control measures (SCM) for safety performance on sites;
2. the development of 'best practice' advice for each SCM in order to help the management to improve its performance;
3. the development of a scoring method to calculate safety performance based on a matrix recommended by Objective Matrix or OMAX approach; and,
4. the demonstration of the applicability of Microsoft Access as a platform for site measurement and data collection applications.

To date the research has also resulted in the publication of a learned journal paper and two refereed conference presentations. More publications are planned.

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ABBREVIATIONS

CDM	Construction Design and Management
ECI	European Construction Institution
HSC	Health and Safety Committee
HSE	Health and Safety Executives
MSHDS	Material Safety and Health data Sheet
PC	Principal contractor
PPE	Personal protective equipment
SC	Specialist-contractor
SCM	Safety control measures
SPMT	Safety performance measurement tool

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

The construction industry has often been criticised for its poor performance in health and safety. Brown (1996) commented that the manner in which safety is managed in the construction industry has not radically changed over the years. Many major companies outside the construction industry have introduced new techniques designed to focus on systems of operation that will improve overall safety performance. Some of these systems have been successfully marketed, but the construction industry in general has failed to respond in similar manner. Brown (1996) adds that there seems to be a strong safety culture in the petrochemical engineering industry compared to the construction industry. In the manufacturing sector, the working environment and the work methods remain essentially unchanged from day to day. On the other hand, on a construction site, the working environment, the work to be done and the composition of gangs of workers changes continuously. The continuous change in working environment generates a greater safety risk for construction processes, which potentially exposes the workers to unforeseen and unaccustomed hazards.

Although legislative instruments and statutory bodies exist to ensure that the impact of these hazards safety risks are prevented or minimised, Anderson (1998) argued that there are several factors in the construction industry that seem to conspire to create 'barriers' to significant widespread safety improvement. These include:

- shortcomings in the present general level of health and safety education;
- general apathy and complacency towards health and safety issues;
- lack of quality and commitment of site management to give site safety issues the priority they need and/or deserve;
- lack of sufficient resources allocated to health and safety;
- overemphasis at site level on production objectives to the obvious detriment of good safe working practices;

- failure of government to put sufficient resources into safety enforcement; and
- the lack of focus on the part of some construction professionals in health and safety issues.

It is generally accepted that safety management is more than a matter of policing 'hard hats, safety boots and first aid facilities'. Successful companies know how to manage what is important to their business. Young (1996) states that when construction quality, low cost or superior services are fundamental to business success, they receive significant management attention. Safety has always been important to construction, but until recently it had not been an essential business driver. The consequence of this conflict is the generally poor safety performance of the industry as a whole.

Current practices in safety management within the construction industry primarily utilise only recorded accident figures. While it is conceded that accident statistics play an important role as prime indicators of safety performance, statistics alone tell little about how accidents occur or about how to reduce the number of injuries (Visser 1993, Haines 1991). For example the method used to record accident statistics in various countries vary. They may include Fatality, Lost Time Injuries (LTI)/ Lost Time Accidents (LTA); and sometimes, but rarely, near misses. Basically only incidences that are recorded are considered in these statistics. Tarrants (1980) cited that injurious accidents are only one consequence of worker behaviour within specified working conditions; as such they reveal very little about antecedent behaviour and machine-environment malfunctions that are important contributors to current and future accident problems.

Staley (1996) claims that accident frequencies and property losses create great impact to any organisation. Not only do they cause delays in operations but also directly and indirectly incur cost. In 1996, the Health and Safety Executive (HSE) estimated that the annual cost to the UK industry from working unsafely in 1995/96 were between £2.9 billion to £4.2 billion. Careil (1991) added that only with proper management commitment, planning and establishment it is possible to achieve a safer working environment that is also cost effective. The realisation of the costs of accidents and human suffering that follows has brought changes in the attitude of management and employees with regards to safety.

The importance of safety becomes diluted if accidents are not occurring and everything is seen as going fine. But the question here is what is fine? Is it by not having accidents? Is it compliance to wearing protective clothing? Is it good housekeeping standards? There are no sufficient guidelines of how health and safety performance in the UK construction industry should be measured. There is no standard method of doing an assessment for any project as required by the legislation. The only method of comparison that is frequently used is accident statistics.

Safety in the workplace is an important aspect of the overall safety in construction. The prevention of accidents is the major aim of any industrial organisation. It is becoming widely accepted that accident prevention is good business practice and that a safe operation is usually an efficient operation. If the industry cannot accurately measure performance, it cannot manage it. Brown (1996) quoted that true safety performance is found in what we do, how we do it, the impact it has on the people the practices are aimed at. When implemented from this perspective safety starts to become performance driven and the goal of integration with defined roles and values becomes a reality.

1.2 STATEMENT OF PROBLEM

The construction industry can benefit from an improved attitude change that cultivates a vision for the future which elevates safety concerns and effectively integrates them into the overall management mix. As reported by Young (1996), the key distinction of outstanding performance of companies outside the construction industry, such as Du Pont a science-based solutions industry, is that these companies have safety as a value enshrined in their culture and every employee. Among the challenges set out under the Movement for Innovation (M4I) (a non-institutionalised body aims to lead a radical change in construction) was for the construction industry, clients and suppliers to radically improve their performance on the respect of people issue of diversity, health and safety, site conditions, welfare and trading (M4I 2000). In the same report, in the keynote speech by the Construction Minister, Nick Raynsford suggested that the industry should double its effort to ensure that everything is done to maximise safety on construction sites through measuring of safety performance.

The need for measuring safety performance was stipulated in many previous research studies. These also have established the need to change from measuring loss-type accidents to measuring the potential occurrence of accidents before they occur i.e. to embrace proactive measurement. The following sections highlight previous authors' endorsement of the need for proactive measurement. Tarrants (1980) stated that it must describe when and where to expect trouble and must provide guidelines concerning remedial actions. Safety performance must be a continuous reporting of changes in safety level. Safety performance should concentrate on measuring safe behaviour instead of unsafe behaviour. Unsafe behaviour causes accidents while safe behaviour prevents accidents.

A key factor in the control and improvement in any performance activity on sites is the ability to measure it. Both Tarrants and Laufer (1986) agree that measurement of safety performance is necessary for the following reasons:

- as a basis for casual factor detection;
- to locate and identify problem areas;
- as a basis for trend comparison;
- to describe the current safety state of an organisation;
- as a basis for predicting future accident problems;
- as a basis for evaluating accident prevention programme effectiveness;
- as a basis for making decisions regarding the allocation of accident prevention resources;
- to assess accident costs;
- to establish long-term accident control; and
- as a basis for quantifying probable risk of injury or other loss.

In the last decade of the 20th century, the UK experienced the most fundamental changes of health and safety regulation than perhaps at any time since the introduction of the first safety legislation in the mid-nineteenth century. The new regulations and in particular the Management of Health and Safety at Work Regulations 1992, built on the skeleton framework for the management of safety contained in the Health and Safety At Work Act 1974 (Booth 1995). There is still much more enforcement that is needed to enhance the safety culture in construction industry.

Smith (1999) agrees that there is a need to develop evaluation tools for construction firms to enabling them to benchmark their overall safety performance. Despite the importance of safety, Helander (1991) reported that very little research focusing on the construction industry has been performed on this subject. The significance of this study is to highlight the importance of developing a single proactive measurement tool to evaluate safety performance on construction sites. Addressing these issues will help to improve the safety culture of the construction industry.

Drawing on the above strong endorsement to the need for proactive safety measurement the research reported in this thesis focuses on developing and providing a single standard measurement system for the construction industry. This was based on the understanding that measurement of safety performance must help prevent accidents and not just record them. The system will provide the opportunity to monitor site activities and provide some form of intervention. It focuses on what are the safety control measures to be measured, how to measure safety performance on construction sites and who should be involved. To address and establish the above issues it was necessary to obtain data from the industrial professionals, especially the safety experts. This was because of their involvement in handling and managing health and safety matters on a project. Additionally other personnel e.g. supervisors, operatives etc. were also used to implement the tool.

1.3 AIMS AND OBJECTIVES

The principal aim of this research is to investigate the current safety measurement tools and provide a standard tool to measure not only the level of safety but to evaluate the effectiveness of safety performance; provide continuous information concerning changes in the safety state of a project and enable identification of potential causes of future loss arising from safety related issues. This was realised through the following three objectives:

1. identify the important proactive safety control measures (SCMs) and indicators of safety performance for construction sites;
2. develop safety performance measurement tool (SPMT); and
3. implement SPMT on on-going projects to demonstrate:
   - its ease of use;
   - it use as an improvement tool; and
   - its reliability.

1.4 RESEARCH METHODOLOGY

The research approach adopted to realise the aim of this study is highlighted in Figure 1.1. This figure shows seven essential stages of conducting the research which included the following:

- literature reviews;
- discussions with the ECI Safety Task Force members;
- Survey I;
- Survey II;
- Survey III;
- developing SPMT; and
- implement SPMT system.

A comprehensive literature review was conducted to study the scenario of safety performance in the construction industry. Kunju Ahmad et al (1998) had discussed the existing safety performance situation in the construction industry which led to this research. The essential information obtained from the literature review includes:

- a list of safety performance measurement techniques used to measure safety;
- a list of reactive factors that affect safety performance;
- a list of proactive factors that affect safety performance;
- a list of accident causation theories;
- matrix used to calculate performance for productivity;
- the various methods to analyse data and information including statistical method and fuzzy logic;
- software that would be suitable to develop the measurement tool SPMT;

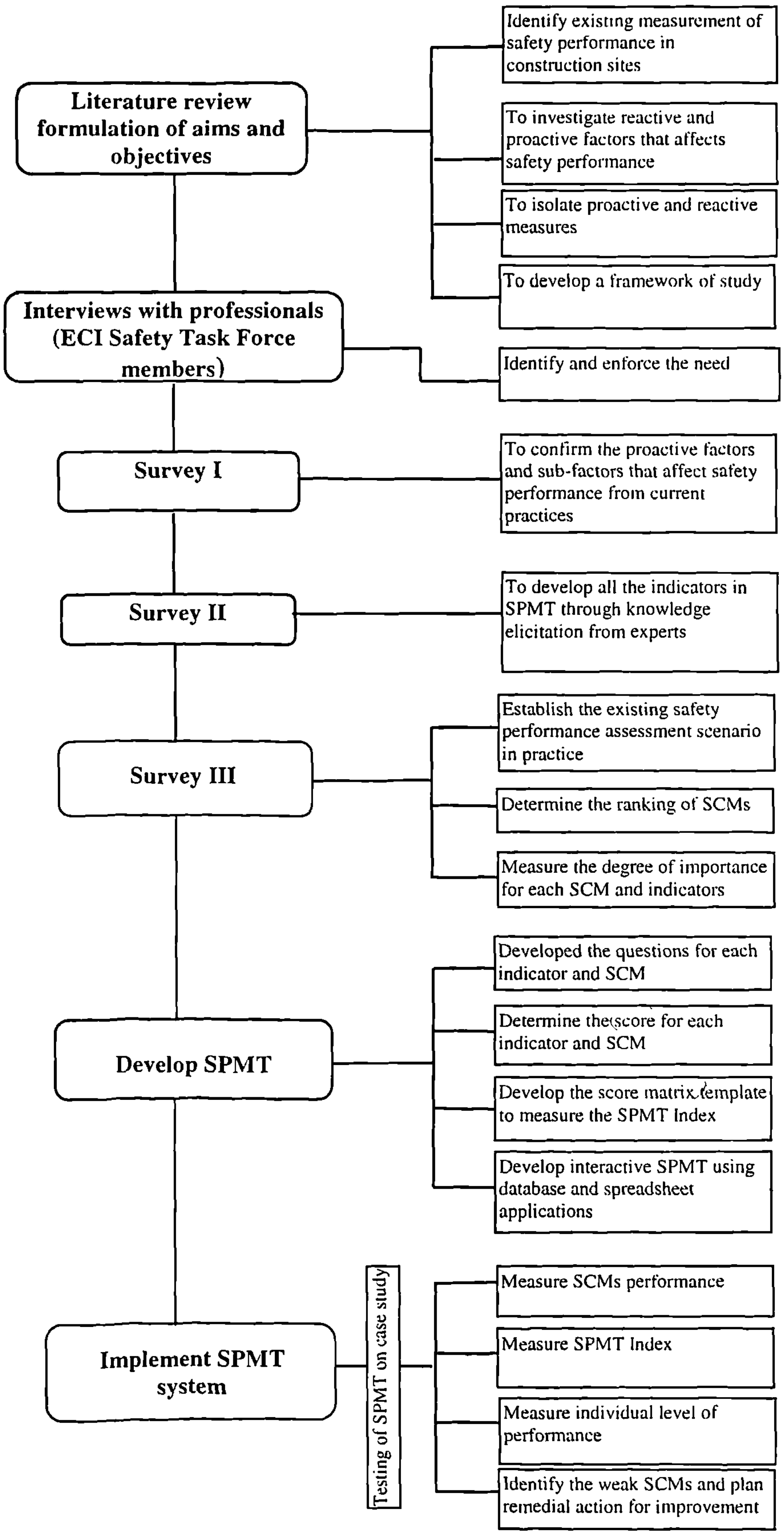


Figure 1.1 – Research methodology

Following an extensive literature review, along with a series of discussions with the European Construction Institute (ECI) Safety Task Force members (refer to Appendix 1.1) the problem focus for this research was identified. The input from the Safety Task Force members was significant especially in Survey I and Survey II. They helped to distribute the questionnaires for Survey I to 182 respondents from Principal Contractors and Sub-contractors. A 35% response rate was achieved. The findings from Survey I helped to identify the safety factors (known here as safety control measures (SCMs)) that affect safety performance on construction sites. From here, the indicators were developed and again the Safety Task Force members' input was used. In all, 303 indicators were refined as significant for Survey II, which was again subjected to the expert opinion through the Safety Task Force members. The response was very positive and recommendations helped to focus on thirty SCMs and reduce the indicators to a smaller number of 143 which is more manageable, more concise and precise.

Survey I and Survey II helped to identify and develop the important safety control measures of safety performance. After carrying out Survey I and Survey II, the important SCMs were identified. The next stage validated the degree of importance for all the selected SCMs and indicators in SPMT on a larger sample. This was done through Survey III. A total of 61 top UK contractors and 90 top mainland European contractors for 1998 were chosen as the sample. In total 42 questionnaires were returned (28% response), of these 31 were from UK contractors (74% of those returned) and 11 were from mainland Europe. The administration of the questionnaire is discussed in Chapter 5.

After the SCMs and indicators had been validated, they were incorporated into the SPMT. The SPMT was designed based on the conceptual framework using the ISO 14001 Environmental Management Standards, BS8800 Guide to Occupational Health and Safety Management System. The next step was to identify how to implement SPMT. It was decided that SPMT would be developed as an interactive and object-based application. SPMT was designed as a computer-aided interactive assessment tool using MS Access and Excel. Chapter 4 discusses the reasons for choosing that software option. When designing the tool the following considerations were taken into account:

- the participants involved in SPMT;
- the methods of assessment;
- the quantitative results from an assessments; and
- the actions taken after an assessment.

The SPMT was designed with the involvement from all the levels of personnel on site. It was necessary to involve the following levels of personnel to ensure that safety is practised by all:

- HQ management;
- site management;
- site supervisors;
- site operatives; and
- specialist-contractor management.

Several different methods of gathering data were used to reduce respondent's bias. They included:

- questionnaires/interviews;
- document checks; and
- observations.

To reduce bias and ensure validity, each SCM has more than one category of respondents answering it or more than one method used to obtain the responses. Once all the respondents have answered the questionnaire, the answers are quantified. For each SCM, the different categories or different methods adopted to obtain responses are combined into a total figure. Detailed explanation of the implementation and calculation of responses is discussed in Chapter 4. The quantitative results are transferred to a score matrix which yields the following results:

- the total points achieved for each SCM;
- the score obtained for each SCM from the matrix (from 0-10);
- the individual SCM indices (after weighting the score);
- the overall SPMT index (the total of all SCM indices); and
- the interpretation of SPMT scores.

For more detailed analysis, the score points achieved for each SCM by each category of respondents can be obtained. The quantitative results identify the SCMs with low scores and also varied responses from different categories. This helps the management to identify what areas to concentrate on and with which category of personnel. The management must understand this exercise is not put blame on any personnel, but rather accept this as a positive way to improve safety performance on construction sites. For example, if the operatives produce a low score, it is not their fault. More likely it is because the safety system is not working effectively.

The analyses used for the surveys are the statistical test and fuzzy logic. Fuzzy logic using group decision making with linguistic majority was adopted to determine the degree of importance for each SCM and indicators. This approach was also used to determine the degree of membership for the fuzzy variable IMPORTANCE for each indicator. The analysis was chosen to ensure that only the important SCMs were included in SPMT. The detailed results of the analyses are discussed in Chapter 7.

SPMT was implemented on four on going project sites. To test SPMT, a periodic assessment was necessary. Due to time constraints and companies commitments, only two sites participated in the second testing. The testing allows four types of comparison to be carried out, namely:

- comparison between the four sites;
- comparison between two sites under the same company;
- comparison of periodic testing (test 1 and test 2); and
- comparison between SPMT performance with reactive data.

The testing identified the weak SCMs and also the influence of the categories of respondents. The results helped management to focus on the weaker safety factors and to plan remedial actions immediately to improve safety performance.

1.5 MAIN FINDINGS

This work generated substantial findings and suggestions that will be significant to the improvement of safety management in the construction industry. While the conclusions of this study are discussed more thoroughly in Chapter 10, some specific major findings include:

- there is a need to enhance the safety culture in the construction industry;
- the construction industry still measures safety performance against accident statistics even though they may adopt a proactive approach;
- there is a critical need for a proactive safety measurement tool for construction industry;
- there is a need to involve all categories of personnel in safety performance assessment;
- the methods adopted to carry out the assessment should be consistent and comprehensive;
- feedback of results of assessment should be informative, able to convey areas of weakness, and able to inform remedial actions; and
- the future potential of SPMT as a generic safety performance measurement tool has been demonstrated.

1.6 FORMAT OF THE THESIS

This thesis comprises of four major components which can be summarised as follows:

1. General investigation on the background of the problem.
2. Developing the safety measurement tool and the safety control measures of SPMT.
3. Investigation and validation of the above issues.
4. Conclusion and recommendations

A diagrammatic guide of the thesis is shown in Figure 1.2 and the four main components of the research are presented in nine chapters and are briefly described as follows:

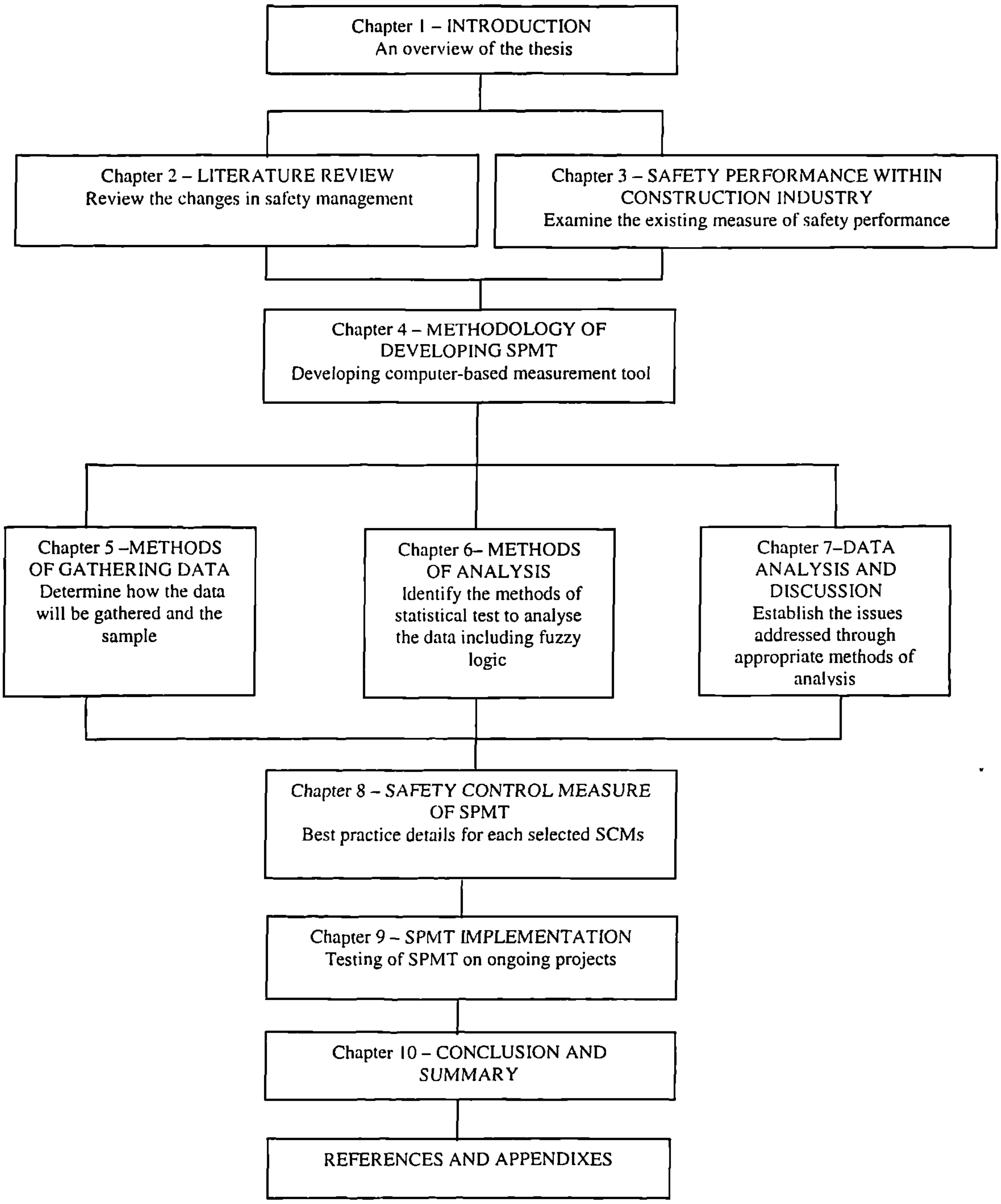


Figure 1.2 – Structure of thesis

Chapter 1 - Introduction

This chapter presents a general introduction to the subject and the specific problem under investigation. It also introduces the aim and objectives, research justification, methodology of conducting this research and a brief summary on the structure of the thesis.

Chapter 2 – Literature review of safety management

From the available literature, this chapter presents the various accident causation theories. It also looks at the evolution of safety management which involves three stages, namely the evolution of law, the evolution of safety activism factors and the evolution of the safety management concept. Lastly this chapter also discusses the way forward to better safety performance.

Chapter 3 – Safety performance in the construction industry

This chapter examines the existing setbacks for safety performance in the construction industry. Reasons why improving safety performance in the construction industry is important are discussed. This chapter concentrates on the main reasons why this study was undertaken.

Chapter 4 – Methodology to develop SPMT

In Chapter 4, the steps taken to develop the safety performance tool (SPMT) are defined as follows:

- goal setting;
- developing the SCMs of SPMT;
- how SPMT will be carried out and who are involved;
- designing the scoring method;
- developing an interactive approach to SPMT; and
- system architecture of SPMT.

Chapter 5 – Methods of gathering data

This chapter discusses the methods adopted to gather the information for the questionnaire design, research population, questionnaire administration and responses. There are three stages of surveys namely Survey I, Survey II and Survey III. Each survey gathered specific information. Survey I identified the factors and sub-factors that affect safety performance on construction sites. Survey II identified the indicators for each sub-factor identified from Survey I. Lastly Survey III determined the relative importance of each safety factor or SCM and indicators.

Chapter 6 – Methods of analysis

The method to analyse the information gathered is defined in this chapter. Normal statistical tools were used to test the information, however, group decision-making using fuzzy linguistic majority was used to determine the degree of truth that 'most' of the SCMs are important. This method was adopted to reconfirm that only the important safety control measures are included in SPMT.

Chapter 7 – Data analysis and discussions

The chapter presents the analysis and statistical tests to establish the findings from all the surveys. The results of the analysis are discussed and conclusions drawn. This chapter also illustrates the use of the fuzzy linguistic quantifier to measure the degree of truth of the responses. In addition statistical tests were also used where appropriate to reaffirm the response between the different groups, e.g. between Principal Contractors and Specialist-contractors.

Chapter 8 – Safety control measures of SPMT

Here all the SCMs that will be included in SPMT are discussed. There are 30 SCMs and each one is examined individually.

Chapter 9 –SPMT implementation

This chapter, SPMT was tested on four different on-going project sites. Analysis of the results was carried out and reported back to the projects.

Chapter 10 – Conclusions and summary

This chapter presents the findings of the research, conclusions drawn from the findings and the recommendations for further research on the subject matter. This chapter highlights the contribution of the research work to the body of knowledge.

Reference and appendices

References related to the research and appendices are presented in this section.

CHAPTER 2

REVIEW OF SAFETY MANAGEMENT LITERATURE

2.1 INTRODUCTION

Safety problems within industry are both complex and deep-rooted. Safety is defined by Ngowi (1996) as the prevention of accidents or mitigation of personal injury or property damage which may result from accidents, while Cox et al (1996) define it is as a state of freedom from unacceptable risk of personal harm. The function of safety is to locate and define an operational error that allows accidents to occur. Peterson (1996) suggested that this function could essentially be achieved in two ways - by studying both the causes of accidents and the effectiveness of known controls being utilised. Many studies have sought to understand why accidents occur (e.g. the domino theory, the loss causation theory).

Over the years, with the advancement of technology, the industry has faced many changes in the working environment including managing safety. Managing safety involves far more than merely imposing rules and policy. Successful implementation demands that safety be integrated as part of the management system itself.

Anderson (1992) reported that an integrated approach to safety management involves three aspects - hardware, software and people systems. He added that previously, large improvements in safety have been achieved through both improved hardware and software, and improved safety management systems and procedures. However, the rate of improvement has since declined such that a different approach, based on improving safety behaviour, is now necessary in order to encourage further progress.

The following literature review focuses initially on the theories of accident causation before discussing the evolution of safety management. The latter is divided into three areas - the evolution of safety laws, the evolution of safety activism aspects and the evolution of safety management. Lastly the discussion concentrates on the way forward to resolve safety problems in the construction industry.

2.2 HISTORICAL FRAMEWORK OF ACCIDENT CAUSATION

Accidents are caused; they do not just happen. Whyte (1960) presented the three essential features of an industrial accident where:

- every accident causes damage or injury;
- the precise outcome is never intended or planned; and
- an accident is characterised by a degree of abruptness

Several authors, including Whyte (1960) and Stranks (1994) agree that after every accident, there is a chain of events that leads up to each outcome and each of these elements acts in a similar manner to form links in a chain. The final link in the chain usually relates to a specific action taken by a worker. This link, when combined with the fact that the injured worker is often the last person performing a task resulting in an accident, provides an explanation as to why such a high percentage of accidents have been attributed to unsafe actions or unsafe conditions.

However, Stranks (1994) states that accident causes are not always as obvious as they first appear to be. He strongly argues that only with persistent investigation can one reveal some obscure yet significant features which entirely change the initial impression of the incident. A review of literature on safety reveals that much research effort has been directed at examining accident records to categorise the most common types of accidents and how they happen. The following is a review of the most prominent and widely disseminated accident causation models on human error theories and the understanding they provide of why accidents happen.

2.2.1 Emergent Theories

The pure chance theory

Stranks (1994) reported the pure chance theory postulates that everyone in the population has an equal chance of having an accident. It suggests that no discernible patterns emerge in the events that lead up to an accident. An accident is usually treated as an act of God, leaving one to accept the fact that prevention is not possible.

The biased liability theory

The biased liability theory reported by Stranks (1994) proposes the idea that, once a person has an accident, the probability that the same person will have a further accident in the future will either decrease or increase with respect to the rest of the population at risk. If the probability has increased, the phenomenon is referred to as *Contagion Hypothesis*. If the probability has decreased, it is commonly known as *Burned Fingers Hypothesis*.

The accident proneness theory

Hinze (1996) and Stranks (1994) both discussed this theory. This theory stipulates that there are innate characteristics in some individuals that are more liable to incur accidents. This means that some innate personality characteristics cause accident-prone individuals to have more accidents than non accident-prone people do. This means that the accident-prone workers make decisions that place them at greater risks. On the other hand, the less accident-prone workers do not expose themselves to such risks.

The theory of unconscious motivation

Stranks (1994) reported that the roots of this lie in psychoanalytic theory with the idea that accidents are brought about by sub-conscious processes, including guilt, aggression, anxiety, ambition and conflict. This theory focuses only on the individuals and the interaction of their perception of the environment with their underlying personality factors.

The adjustment stress theory

This theory, discussed by Hinze (1996), was developed by Kerr in 1950. It states that workers under stress will face a greater probability of being involved in an accident. Stress working environment provides a negative climate for workers. Stress could exist from either job-related matters or non-job related matters. Job-related matters may have developed from the direct outgrowth of conditions that exist at the work place.

Goals of freedom alertness theory

Following the stress adjustment theory, Kerr further developed a second and complimentary theory called the goals of freedom alertness theory (Hinze 1996). In contrast to the stress adjustment theory, this theory focuses on the goal driven aspects of human behaviour. Workers will set goals for themselves and want to see the results of their efforts. It is important for the workers to have flexibility in the work environment to pursue those goals such that by being given the latitude to pursue these goals, they will concentrate work efforts on task accomplishment. This in turn is conducive to safe work practices in that better safety performance can be realised when there is a psychologically rewarding work environment.

2.2.2 Domino theory

All accidents involve one or more events which may lead to the accident and possible injury. Developing this concept, in 1931, Heinrich introduced a theory called the domino theory. The model outlined five basic causes of accidents as detailed in Figure 2.1.

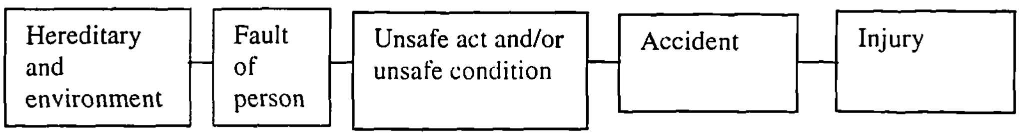


Figure 2.1 – Heinrich's domino theory (Liska 1993)

1) Hereditary and social environmental factors, leading to
2) a fault of the person consisting of the proximity reasons for
3) either an unsafe act or unsafe condition, which result in
4) the accident which may lead to
5) the injury or loss.

Several authors have discussed Heinrich's theory including: Cox (1996); Peterson (1989) and Liska (1993). These authors reported that the five stages in Heinrich's domino theory can be envisaged as a sequence of five dominoes: if the first domino falls, it will automatically knock down the second domino which in turn will knock down the third and so on until the final domino. According to Heinrich, removing any one of the first four dominoes will break the sequence and thus prevent an injury from happening. Removing the key domino, that is the third domino (unsafe act/situation) will prevent accidents happening. Heinrich is known to have popularised this 'non-injury accident' concept which is defined as an unintended event with the potential to cause injury as well as damage to the plant, equipment or material but not actually cause injury or damage. According to Heinrich, 88% of all accidents were caused by unsafe acts while only 10% were caused by unsafe conditions. 2% could not be categorised.

2.2.3 Theory of multiple causation

Safety analysts have preached the Domino Theory for many years. This theory was intended to provide a practical system for removing the events that cause accidents. However Weaver (1971) and Peterson (1989) felt that its interpretation had been too narrow. Peterson claims that after identifying the unsafe act and/or unsafe condition following an accident, there are still many other causes that are being left unmentioned. The author argued that identifying an unsafe condition or act might not necessarily remove the real cause of potential accidents. According to Peterson, behind every accident lie many contributing factors, causes and sub-causes.

Weaver too commented on the old domino theory of accident causation. He suggested that the unsafe acts and conditions be viewed, not as causes of accidents, but rather as symptoms of things wrong in the management system. The argument here is based not on looking at the proximal cause of the accidents, but rather looking at as many factors as seem possible. The theory of multiple causation suggests that it is important to trace all the contributing factors to determine the underlying causes (Figure 2.2).

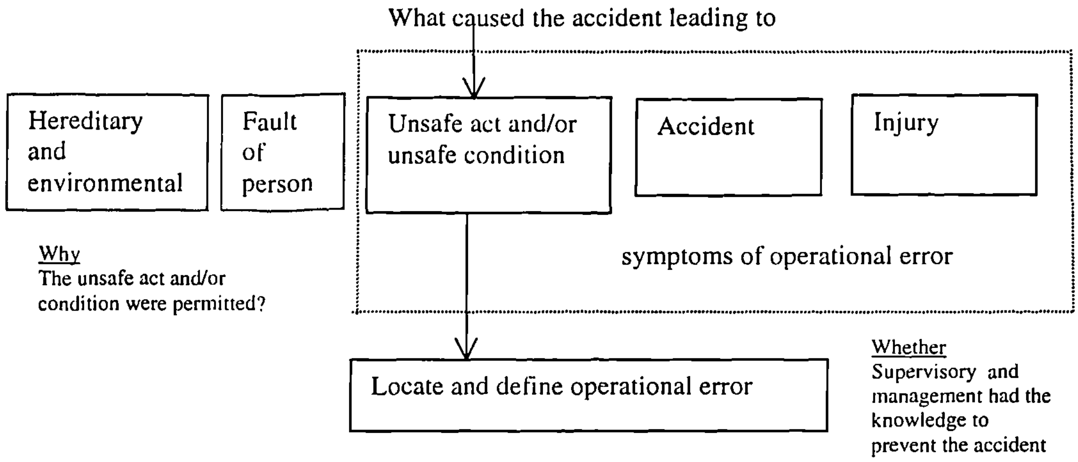


Figure 2.2 – Weaver model of accident causation process (Peterson 1996)

Every accident opens a window through which symptoms and procedures can be observed. Different accidents may unearth similar things that might be wrong within the same management system. The theory of multiple causation states that these factors combine together, in random fashion, to give rise to accidents. A good example illustrated by Peterson clearly demonstrates the difference between the domino theory and multiple causation theory.

Accident:	Falling off a stepladder
The unsafe act:	Climbing a defective ladder
The unsafe condition:	A defective ladder
The correction:	Replace the ladder

The above would be a typical scenario found on site under the domino theory. In a similar way, looking at the same accident case under multiple causation produces a number of questions:

1) Why was the defective ladder not found during normal inspection?
2) Why did the supervisor allow its use?
3) Didn't the injured employee know it should not be used?
4) Was the employee properly trained?
5) Was the employee reminded not to use the ladder?
6) Did the supervisor examine the job first?

Answers to the questions would lead to the following corrections:

1) An improved inspection procedure
2) Improved training
3) A better definition of responsibilities
4) Pre-job planning by supervisors

Multiple causation theory deals with the causes of accidents and not just the symptoms. Removing the symptoms will not necessarily mean that the accident or injury will not reoccur. As can be seen from the above example, removing the ladder does not eliminate any chances of the fall from happening. In order to achieve a permanent improvement, the accident root causes must be dealt with.

2.2.4 Loss causation model

Bird et al (1985) introduced the loss causation model (Figure 2.3) which was also based on the idea of Heinrich. The result of accident is loss and the most obvious losses are harm to people, property or process in which the effect may be small or big, major or minor losses. Bird et al discussed this theory in detail as below:

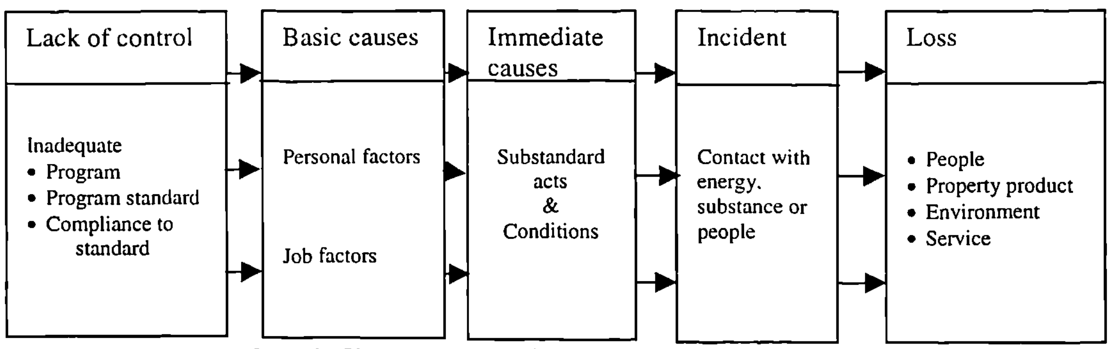


Figure 2.3 - Bird's loss causation model (Bird et al 1985)

Basic causes

Basic causes are the disease or real causes behind the symptoms; essentially the reasons why the substandard acts and conditions occurred; or the factors that, when identified, permit meaningful management control. Often, these are referred to as root causes and can help explain why people perform substandard practices or why substandard conditions exist. In other words, basic causes can be described in two categories - personal factors and job factors (work environment) – and it is these which cause or permit the substandard acts and conditions. Behind these causes are the deficiencies in the management systems.

Immediate cause

The immediate causes of accidents are the circumstances that immediately precede the contact. Frequently they are labelled the unsafe acts (behaviour that permits the occurrence of an accident) and the unsafe conditions (circumstances which could permit the occurrence of an accident). However modern managers tend to term it as substandard practices and substandard conditions for the following distinct advantages:

- it relates practices and conditions to a standard - a basis for measurement, evaluation and correction;
- it somewhat minimises the finger-pointing stigma of the term 'unsafe act'; and
- it broadens the scope of interest from accident control to loss control, encompassing safety, quality, production and cost control.

These immediate causes are only the symptoms and treating symptoms will not prevent reoccurrence. It is therefore important is to treat the root causes or the basic cause.

Incident/contact

This is the event that precedes the loss - the contact that could or does cause the harm or damage. When potential causes of accidents are permitted to exist, the way is always open for contact with a source of energy above the threshold limit of the body or structure. When substandard conditions are allowed to exist (such as upgraded machine tools) or substandard acts are permitted (such as cleaning with petrol), there is always the potential for contacts and energy exchanges which harm people, property and/or process.

Loss

As mentioned earlier, the result of an accident is loss and two such implied and important related losses are 'performance interruptions' and 'profit reduction'. Once the sequence has occurred, the type and degree of loss are to some extent a matter of chance and the effect may range from insignificant to catastrophic - from scratch or dent to multiple fatalities or loss of a major item of plant. Regardless of whether people are hurt, accidents do cost money and indeed the injury and illness cost is a relatively small part of the total cost.

The arrows in Figure 2.3 show multilinear interactions of the cause and effect sequence. As well as with multiple causes, the model also reflects opportunities for control and these can be grouped into three major categories or stages of control:

- stage 1 - pre-contact;
- stage 2 – contact; and
- stage 3 - post-contact.

Stage 1 includes everything we do to develop and implement a programme which a) avoids the risks, b) prevents the losses from occurring and c) plans actions to reduce loss if and when contact occurs.

Stage 2 is where accidents usually involve contact with energy or substance above the threshold limit of the body or structure and which may or may not result in loss, depending on the amount of energy or substance involved. Effective controls keep the exchange at a minimum, resulting in minor rather than major losses, and 'close calls' rather than accident losses. These measures do not prevent the contacts or incidents, but they do contribute significantly to the control losses.

Post-contact controls do not prevent the accident but they may minimise the losses. They can mean the difference between injury and death; between reportable damage and total loss, between a complaint and a lawsuit, or business interruptions and business closing.

The complexity of events leading to loss can, in one way, be viewed quite positively. It shows that there are many opportunities to intervene or interrupt the sequence and thus control the loss. Bird et al claimed that a majority of accidents involve both substandard practices and substandard conditions. However even after uncovering all of these causes, there is more to be done. One should determine what deficiencies in the management system (e.g. poor hiring and placement or lack of training) permitted or caused both these personal and job factors.

2.2.5 Active and latent failure theory

Another prominent researcher in accident causation modelling is Reason (1997). He identified two types of accidents as essentially those that happen to individuals and those that happen to organisations. Organisation accidents have multiple causes involving many people operating at different levels of their respective companies. By contrast, individual accidents are ones in which a specified person or group is often the agent and the victim of the accident. It is not wrong to say that individual accidents are of an entirely different nature to the organisational accidents, for the latter can have devastating effects on uninvolved populations, assets and environments especially where they involve major projects such as petro-chemical plants. Reason continues by arguing that individual accidents have remained unchanged over the years whereas organisational accidents are a product of technological innovations and are therefore ever changing.

Reason developed a basic framework showing the relationship between the three elements - hazards, defences and losses - and how they occur. The essence of this framework is that when an individual performs unsafe acts, that breaches defences (or occurs in the absence of defences), an accident can occur. The defences are breached essentially by three factors that are human, technical and organisational. Human rather than technical failures played the dominant roles in all those accidents and further close examination shows the need to distinguish two ways in which human beings contribute to the breakdown of complex systems. Reason identified the two failures as follows:

- active failure: those errors and violations having an immediate adverse effect; and
- latent failures: these are decisions or actions, the damaging consequences of which may lie dormant for a long time only becoming evident when they combine with local triggering factors (that is, active failures, technical failures, etc) to breach the system's defences as in Figure 2.4.

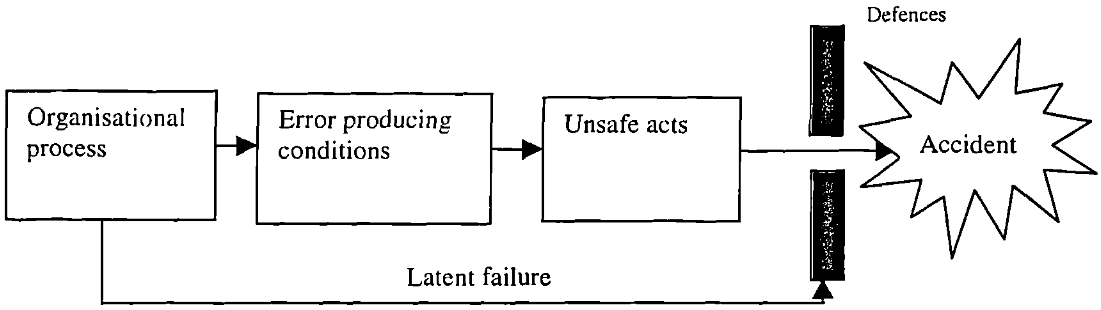


Figure 2.4 – Reason's framework of accident causation (Reason 1997)

Unsafe acts

Unsafe acts can be failures to perform actions to maintain the defences, errors of omission such as failing to start emergency equipment, or actions that cause or exacerbate the abnormal event (errors of commission). These unsafe acts can be active or latent. Wreathall et al (1993) claim that there are varieties of unsafe acts – slips, lapses, mistakes and circumvention as illustrated in Figure 2.5. Slips and lapses are unsafe acts whereby what was performed was not what was intended, for example mis-selecting a control or skipping a step in the procedure. Mistakes are failures where the intentions are erroneous, but purposefully executed. The third category, circumvention, is the deliberate but non-malicious breach of safety rules. These are often done for good reasons such as performing a task quickly or overcoming some organisational 'barrier'.

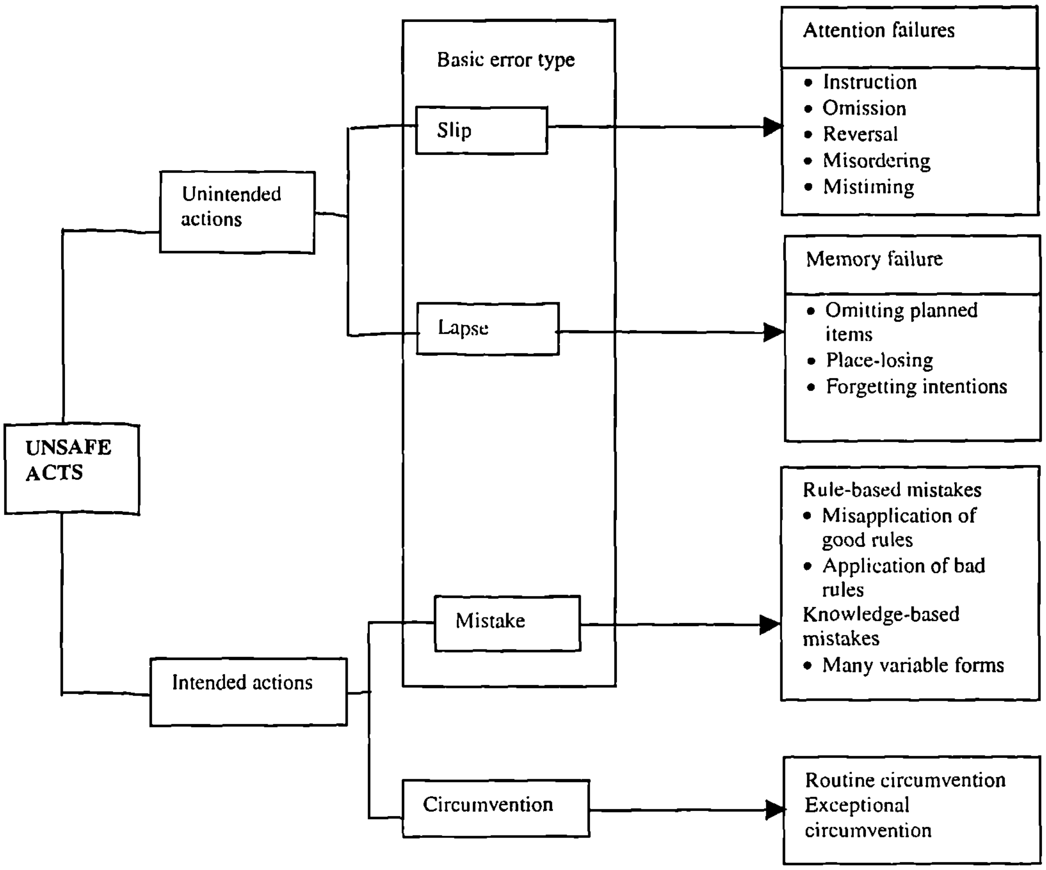


Figure 2.5 - Categories of unsafe acts (Wreathall et al 1993)

Error producing conditions

Wreathall et al (1993) developed a framework of the error producing conditions. This structure has been developed to portray a more diverse set of influences on job performances that include traditional ergonomics issues such as human-factors, engineering, training and environment. It also includes psychological and sociological factors, such as team structure, professionalism, policy consistency and the reward/punishment structure of the work unit.

Organisational process

It is recognised that only a limited amount of work has been performed on evaluating how organisational processes influence safety. A view of organisational activities has been presented by Reason in terms of organisational 'core processes', that is those activities that must be accomplished within the organisation in order to manage safety. Reason has described the four basic processes of a technical system comprising Design-Build-Operate-Maintain (D-B-O-M) within management, and communication acting between them. While these apply at the working level, there are two additional processes at the technical level - goal statement and organisation. Beyond the organisation is an additional process – regulation. Using this concept, Reason has developed a set of eleven organisational failure types (Ofts) that identify inadequacies in these processes. These include incompatible goals, inappropriate organisational structure, inadequate communications, poor planning and scheduling, poor procedures, poor training and so on. Once identified and interpreted in an operational context, these indicators can be used to monitor the safety 'health' of the organisational process.

2.2.6 Staley accident causation model

In 1996, Staley et al (1996) created a simple, four-stage causes of accident sequence as shown in Figure 2.6 to be applied when analysing human factors within management and organisation.

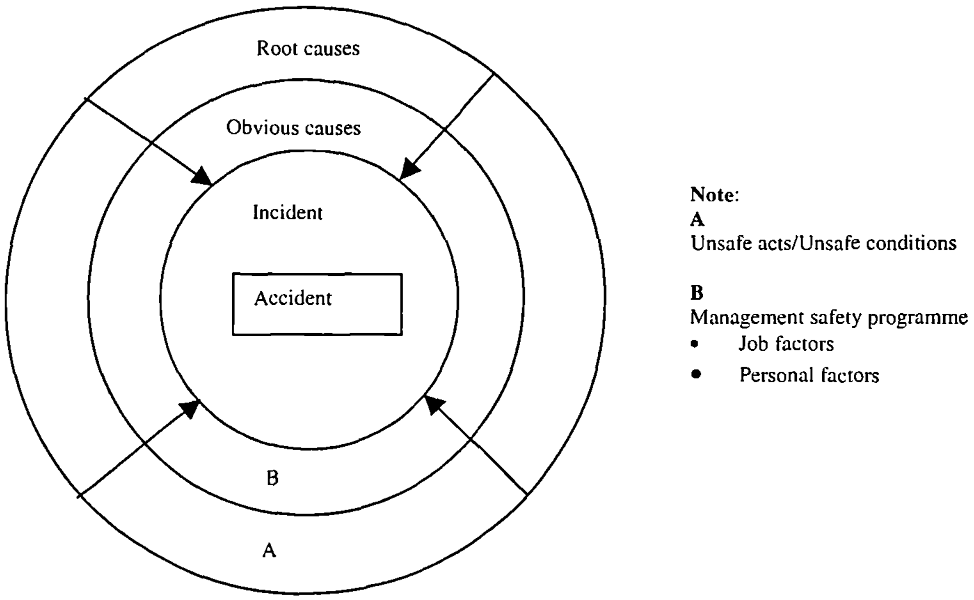


Figure 2.6 - Causes of accidents (Staley et al 1996).

Root causes

Root causes or core causes usually initiate within a poor management system and then go on to lead to problems such as personal factors (such as lack of knowledge, ability skill), job factors (such as poor or inadequate work practice, low standard) or communication. It is these latent failures which create unsafe acts or unsafe situations.

Obvious causes

The obvious causes of accidents are unsafe acts or unsafe conditions. An unsafe act is any behaviour that increases the likelihood of an accident. An unsafe condition is a circumstance, not necessarily caused by the action of people, which may lead to an accident if not rectified.

Incident

At this stage, the root causes and the obvious causes are reacting together to produce a transfer of energy that results in an incident. Therefore if there is a potential cause of an incident, there is always a way open for a transfer of energy. When too much energy is transferred, incidents will occur.

Accident

An accident will occur if the incident results in either personal injury, damage to equipment or loss. When an accident occurs, it will involve both the direct and indirect cost.

2.2.7 The distraction theory and physical hazards

The distraction theory, developed by Hinze (1996) has three components. The first relates to the probability of injury occurrence and is measured along the y-axis of a typical chart using x-y co-ordinates. The x-axis represents a measure of the probability of achieving a particular work task; more commonly referred to as a measure of productivity (Figure 2.7).

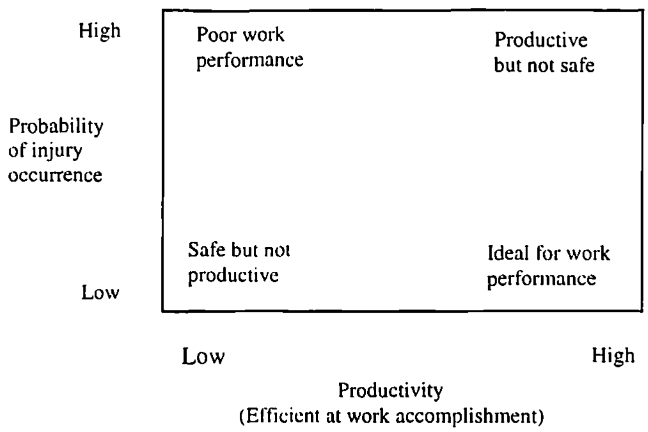


Figure 2.7 –Primary axes depicting the distraction theory (Hinze 1996).

From figure 2.7, it can be seen that performance can be either ideal (safe and productive), poor (unsafe and unproductive), productive but not safe, or safe but not productive. The third element encompasses the mental distraction(s) experienced by the worker. The first type to be addressed consists of unsafe physical conditions. This is a dynamic variable as the worker may or may not be influenced by the distraction and the degree to which a worker is influenced will be determined by the extent to which the worker is focused on the distraction. Safe work performance will be achieved when the worker is aware of and responsive to the distraction or the unsafe physical condition. If the worker performs the task with little regard of the unsafe physical conditions, he or she will be likely to be more productive, but at an increased risk of accident. The concept of the theory in which unsafe physical conditions contribute the distraction is illustrated in Figure 2.8.

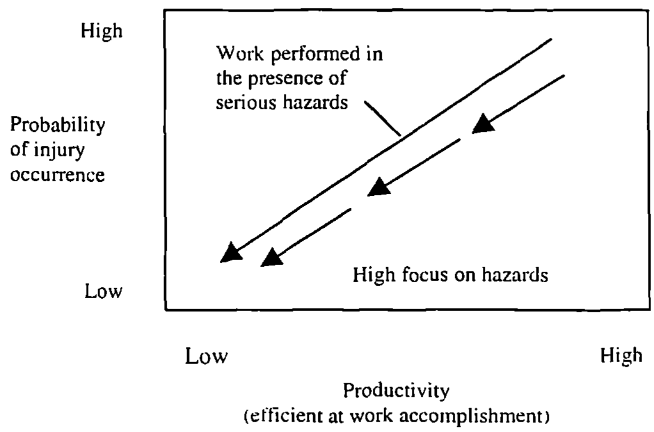


Figure 2.8 - Productivity and safety as influenced by serious hazards (Hinze 1996)

From figure 2.8, it is apparent that productivity and safety are not jointly achievable where serious hazards exist. In this situations, actions are taken to reduce the chance of an injury, however with these steps; the work task achievement is jeopardised. Thus, productivity begins to decline as the worker devotes more attention to the hazards.

The conclusion that safety and high productivity are not jointly achievable when a serious hazards exist in a place of work may seem unpalatable. However the theory does not state that one has to choose between being safe and being productive.

2.2.8 The distraction theory and mental diversions

The previous examples have described situations where a worker's attention would be distracted by physical hazards. Hinze's research has concluded that in the case of the distraction theory those distractions or mental diversions that can be the results of factors other than unsafe conditions must be addressed. Mental diversions can take many forms and can be defined simply as different issues or concerns that can occupy the mind. The diversion may be brought to the job or they might be generated by conditions existing on the job.

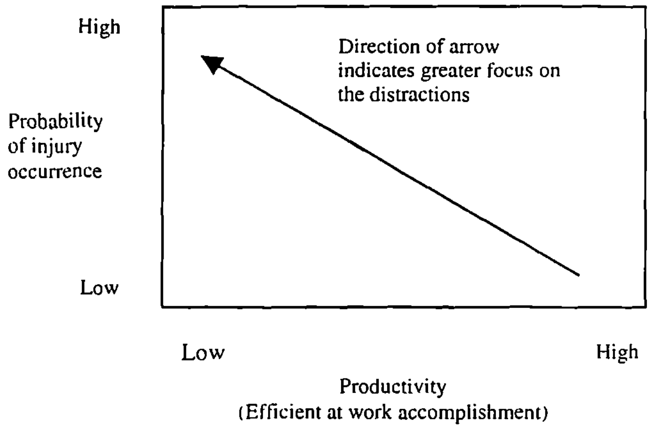


Figure 2.9 – Productivity and safety as influenced by mental diversions (Hinze 1996)

As illustrated in Figure 2.9, greater focus on a mental distraction will divert attention from the work task and therefore compromise productivity. At the same time, focus on the distraction will also make the worker less aware of the work environment and increase the probability of injury occurrence. Thus, safety and productivity are jointly compromised by mental diversions, provided the distraction is not related to the physical hazards that exist in the workplace. The distraction theory is a practical portrayal of how accidents might be caused and can explain accident causation in relation to productivity.

2.2.9 Summary of Accident Causation Theory

The previous sections discussed the development of accident causation theories which are summarised schematically in Figure 2.10. As illustrated, the causes have undergone a rigorous change from purely an act of God to human factors. The domino theory overrides the emergent theories stating the obvious and simple truth that people and not things cause accidents. This theory has been used by many safety experts to demonstrate that loss can be prevented if the unsafe act or the unsafe condition were removed.

But over the years, this theory was criticised and new theories begin to emerge. It was proved that behind every accident there lie many contributing factors, causes and sub-causes. The theory of multiple causation states that these factors combine in random fashion will cause accidents. Therefore, identifying an unsafe act or unsafe condition merely means identifying the symptoms and not the actual cause. Thus dealing with the symptoms will not remove the root causes, allowing it to remain there and eventually lead to another accident or incidents. Root causes usually lie in poor management systems which would lead to other latent failures (such as lack of experience, lack of knowledge or poor job skills) or job factors (inadequate working environment) or ineffective communication.

Correcting the root causes would result in removing the real causes of accidents thus creating permanent improvement. Removing the root causes of accidents would mean removing the causes of other operational problems. The overview of accident theories gives a clear picture that improvement must start with and be driven by the management.

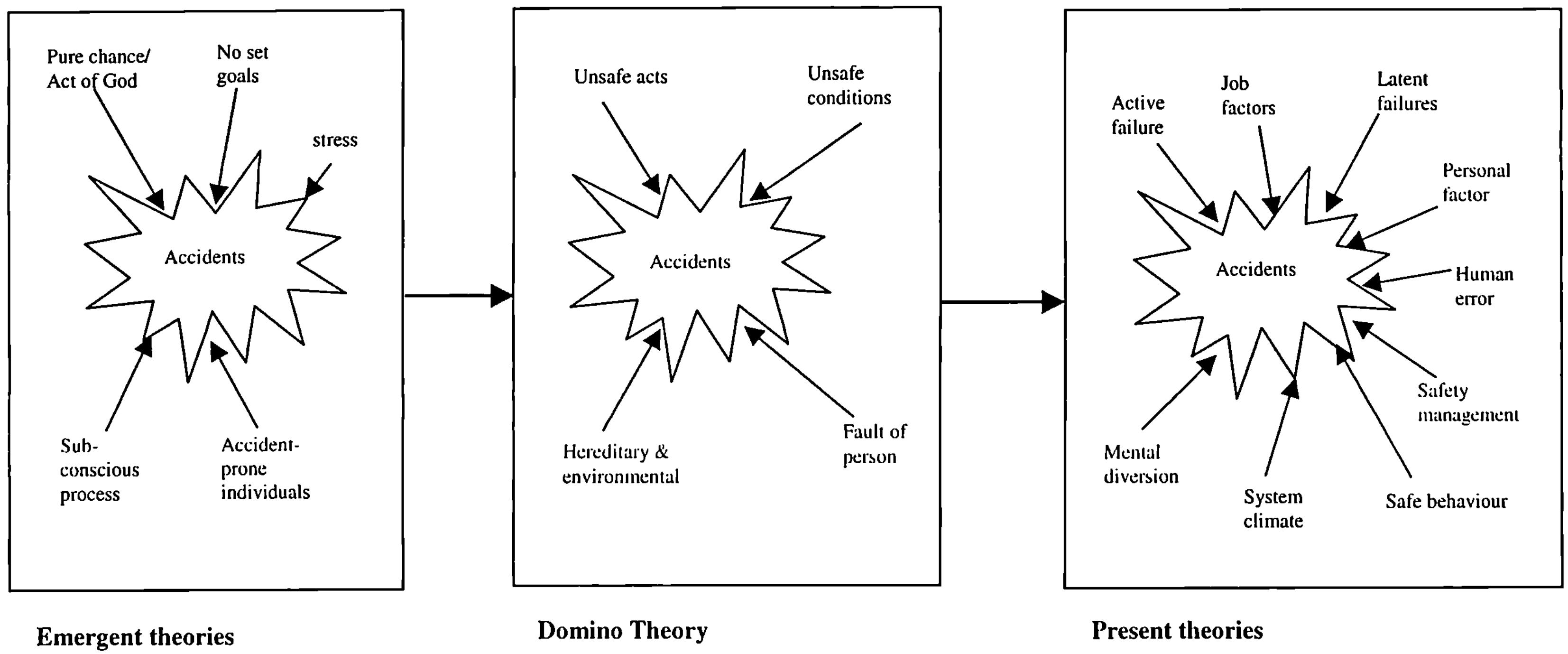


Figure 2.10 – Summary of causes of accidents based on the accident causation theories

2.3 THE EVOLUTION OF SAFETY MANAGEMENT

The research into accident causation theories presented in Section 2.2 shows the growing concern to improve safety performance in the industry. Increasingly, through the industrial revolution in Europe and USA, 'man-made' accidents started to become more widespread and have greater consequences. Wreathall et al (1993) concluded that this revolution brought about many changes to the industry in the early 1900s, which resulted in:

- equipment was not designed with operator safety in mind;
- machines were not guarded;
- people were unskilled and untrained;
- work hours were much longer;
- general cultural and educational levels were lower;
- employers were less employee-orientated;
- employees had more fatalistic attitude; and
- safety statistics and laws were sparse.

The coming of the industrial revolution brought many changes in the way people work with more emphasis being placed on the role of management, human behaviour, human error and others. These changes have slowly affected the way in which safety is managed and can be discussed in terms of three aspects:

- evolution of the law;
- evolution of safety activism factors; and
- evolution of management concepts.

2.3.1 Evolution of the Law

Several authors have discussed this topic in detail including Denton (1982), Bird et al (1985), Anderson (1992), and Ridley (1994) analysing how legislation has affected safety management. This section summarises their writings. The modern orientation of safety management began many years ago with the coming of the industrial revolution. The United Kingdom's legislation on occupational health and safety began on in 1833 when an Act was passed to 'regulate the labour of children and young persons in the mills and factories of the United Kingdom'. This law was occasioned by the report of the Factory Commission on employment conditions in the textile factories and during this time the King also appointed four inspectors. The 1833 Act dealt mainly with the hours of employment and education of the factory children.

Legislation was extended in 1844 owing to the requirements for the fencing of dangerous machinery and for reporting of accidents. The 1833 Act had given the inspectors the power to convict on view, an unprecedented mixture of the executive and judicial functions. However the 1844 Act removed the judicial function and from then on all legal battles had to be fought in the courts.

The wider scope of work and the progress of the industry brought the need for modifications in law and in practice. With the rise of industrial disease, especially lead poisoning, special rules for dangerous trades were introduced. The consolidating and amending Act of 1901 covered a wide variety of premises and brought additional duties, as did the increasing number of special regulations.

With the passing of two world wars, employees faced rapid changes in the technological era. Employers provided better working conditions beyond the minimum requirement and the increased speed and complexity of new machinery provided greater risk. Workers had a wider expectation of life. They began to demand greater attention to conditions of work with regard to health and safety. Among the workers and the trade unions, preoccupations with danger money compensation increasingly gave way to demands for improved protection, fuller information on risks and for participation in reducing the risks. Even the members of the public began to realise that risks were not confined to employed persons.

The building boom itself produced its own crop of fatal and serious accidents. As technological developments brought new major hazards to life and health, more and more attempts were made to discover the root causes and methods of prevention. The existing legislation on health and safety was insufficient to meet the modern working conditions and trade unions were demanding more inspectors and more participation of their members in work safety committees. It was not until 1937 and the Factories Act, that the hazards of building and civil engineering were recognised and given their own set of regulations - the Building (Safety, Health and Welfare) Regulations 1948. These regulations were in turn superseded by the four sets of Construction regulations in 1961 and 1966 which remain in force today. The first two Construction (General Provision) Regulations 1961 and Construction (Lifting Operations) Regulation 1961 – came into operation in 1962 and civil engineering work was covered for the first time by these legal requirements. They were then followed by the Construction (Working Place) Regulations 1966 and the Construction (Health and Welfare) Regulations 1966.

Lord Robens undertook a major revision of the Factories Act 1961 culminating in the Health and Safety at Work Act (HSWA) 1974 which itself created the Health and Safety Executive (HSE) and the Health and Safety Commission (HSC). The HSWA laid down new duties on employers and employees alike, but under it the existing health and safety legislation was also scheduled to be observed as relevant statutory provision. The HSWA remains a flexible instrument under which detailed regulations and approved codes of practice may be made as it requires keeping legislation up to date for many years to come.

The Health and Safety at Work Act 1974 (HSWA) essentially covers all people at work, whether they be employers, employees or self-employed, with the exception of domestic servants in private households and some public transport workers both covered by other Acts. Additionally the Act protects the general public in the case where their health and safety may be affected by the work activities of others, for example by contractors.

Regulations made under the HSWA which apply only to construction are:
- Construction (Lifting Operations) Regulations 1961;
- Construction (Head Protection) Regulations 1989;
- Construction (Design and Management) Regulations 1994; and
- Construction (Health, Safety and Welfare) Regulations 1996.

Construction (Lifting Operations) Regulations 1961

These deal with the construction, erection, inspection, examination and use of lifting appliances and lifting gear (tackle) on construction sites and cover such plant and equipment as cranes, hoists, winches, piling frames, shears legs, excavators, draglines, pulley blocks, overhead runaways, cableways, slings, shackles, eyebolts, hooks, wire and fibre ropes. These regulations require both the plant and equipment be kept in good order for safe use and that they are used safely.

Construction (Head Protection) Regulations 1989

These regulations place a duty on employers to provide suitable head protection for employees, to maintain it and to replace it whenever necessary. They also impose a duty on employees provided with head protection to wear it whenever required to do so. The regulations are also applicable to self-employed workers on site who have a duty to provide themselves with suitable head protection and wear it wherever required, as well as maintaining it and replacing it whenever necessary.

Construction (Design and Management) (CDM) Regulations 1994

The CDM Regulations were enacted in 1995. The CDM Regulations brought about a change in the distribution of the responsibility for health and safety of construction workers being more evenly spread throughout the project team – essentially moving the responsibility from the contractor's shoulders during the construction stage to the designer and client as well. The CDM Regulations place specific duties upon clients and contractors to rethink their approach to health and safety. The aim is to ensure that safety is co-ordinated and managed effectively throughout all stages of a construction project from conception, design and planning through to the execution of work on site and subsequent maintenance and repair and even to final demolition and removal (Croner 1996). CDM's aim is to avoid, minimise and combat health and safety risks suffered by workers and others engaged in all types of construction work or those affected by their work.

The CDM Regulations generally apply to all construction work including:

- alteration and conversions;
- fitting out;
- commissioning;
- repair, upkeep, redecoration and general maintenance (including certain cleaning operations);
- demolition or dismantling structures; and
- preparation works including site clearance exploration (not site surveys).

The regulations attempt to ensure all parties involved in the construction process share responsibilities for health and safety matters are summarised in Table 2.1.

Table 2.1 – Statutory appointment of responsibilities under the CDM Regulations 1994 (Grinfield et al 1999)

Clients (or Client's agent) but excluding domestic clients	Designer	Planning supervisor	Principle contractor
Appoint a Planning Supervisor.	Make Client aware of their duties.	Ensure the Heath and Safety Executives is notified of the works.	Co-ordinate and manage health and safety issues during the work.
Provide information to the Planning Supervisor on health and safety matters.	Give due regard to health and safety matters in all design work, including when the full regulations do not apply (for instance, work for a domestic Client).	Ensure co-operation between Designers.	Develop the Health and Safety Plan before construction starts and keep it up to date during the construction phase.
Appoint a Principle Contractor.	Provide adequate information about the health and safety risks of the design to all relevant parties.	Ensure that Designers comply with their duties.	Co-operate with the Planning Supervisor and Designers.
Check and ensure the competence on health and safety matters of those appointed by him.	Co-operate with Planning Supervisor and other Designers.	Ensure a pre-tender stage Health and Safety Plan is prepared.	Prepare risk assessments/method statements when required.
Ensure that a suitable construction stage Health and Safety Plan has been prepared by the Principal Contractor before the start of the work.		Advise the Client when requested to do so, in particular on competence and adequacy of resources of contractors and designers on health and safety matters. Ditto to Principal Contractor.	Collect and collate details of services, plant and equipment that are part of the structure from specialist suppliers and installers, and pass it on for incorporation into the Health and safety File.
Ensure that a Health and Safety File is kept available for use.		Ensure that a Health and Safety File is prepared.	

Five years after the implementation of the CDM Regulations, questions still remain as to whether the system is working as effectively as was envisaged. A recent survey by Preece et al (1999) showed that 91% of the respondents believed that the CDM Regulations were a natural progression of health and safety management. The same group of respondents agreed that the CDM Regulations will be able to reduce the number of accidents whilst 95% of respondents agreed that there is a need for some form of training related to the CDM Regulations. Evidence from the survey strongly suggests that duty holders have a closer working relationship and that communication has improved with an 87% agreement. A major reason for this strong agreement arises from the placement of responsibility on those parties that had previously been avoided. As a result people are forced to communicate with other parties on a project and thus recognising it to be a useful tool for the understanding and smoother completion of a project.

However, 68% of the respondents felt that the Health and Safety Plan required by the CDM Regulations is filled with information regarding the company's safety policies which has no relation to the project in question. Results from the survey also show that 65% of the respondents believed that the position of Planning Supervisor is an integral part of the design team. However, the Planning Supervisor should not be necessary on small to medium size projects because many parties co-ordinate well together already and the CDM Regulations rely on the ability of the Client to understand their role and not the Planning Supervisor.

The respondents did suggest that the duties of the Planning Supervisor should be given to the Principal Designer and that the role of the Planning Supervisor as a separate function should disappear. This would result in decreased paper work much of which was seen be to instigated by the Planning Supervisor to justify their role. In essence the role of the Planning Supervisor needs a clearer definition or removing all together.

Construction (Health, Safety and Welfare) Regulation 1996

This Regulation came into force on 2nd September 1996 revoked over 100 existing regulations and replaced with approximately 30 regulations which are intended to be 'goal setting' rather than 'prescriptive' in their approach. The regulations which were revoked are as follows:

- Engineering Construction (Extension of Definition) Regulations 1960;
- Construction (General Provision) Regulations 1961;
- Construction (Working Place) Regulations 1966;
- Construction (Health and Welfare) Regulations 1966;
- Engineering Construction (Extension of Definition) (No. 2) Regulations 1968; and
- Construction (Health and Welfare) (Amendment) Regulations 1974.

The main benefit of this new Regulation are that they simplify the former requirements relating to construction activities, cover all construction work as defined by the CDM Regulations and take account of:

- modern construction activities and techniques, e.g. proprietary trench support mechanisms and the use of abseiling equipment;
- specific or emerging construction safety risks; and
- new requirements relating to construction health and safety, e.g. the CDM Regulations.

2.3.2 Evolution of the Safety Activism Factors

Many factors influence the decision of modern managers regarding health and safety. The factors that activate the awareness of safety are known as safety activism factors and were introduced by Findlay et al (1980). They discussed these factors as follows:

Trade Unions

Collective bargaining has played a role in workplace safety improvements. Trade Union's influence can be exerted not just in direct negotiations, but also through financing or supporting of health and safety and research, lobbying for health and safety legislation and backing of liability suits filed by union members.

Consumerism

Consumerism has a more significant influence on health and safety management and has emphasised growing concern over dangers to people from manufactured products. As a consequence, many hazardous substances or products have been banned or at least severely restricted e.g. asbestos.

Courts

Rise in consumerism has created a tendency to sue for injury, aggravation or even affront. The snowballing sequence in business losses, insurance premiums and court costs borne was beyond control. Safety management leadership can be the critical factor in regaining control.

Technology

Technology has created a need for extensive, dynamic safety programmes. Machinery and equipment are consistently being developed to provide better performance. Many tasks are becoming exceedingly complex and demanding with the potential consequences of errors more costly. The psychological effects of these advances have lead to a greater insistence on safety. Where risks had previously been assumed. people now feel that things can and should be safe. As a result, management decision making has been broadened to encompass potential applications of sophisticated techniques, such as system safety analysis and a concern for the entire useful life of a product.

Workforce changes

The character of the workforce has undergone great changes. Employees are given equal opportunities without bias as required by law and the scenario of the workplace has changed from male dominant to a more women-working environment. Besides employing female workers, people with disabilities are also employed within their limitations. Workers tend to be better educated and informed and have higher expectations from their jobs. Each of these changes in the workforce introduces new demands and new challenges for safety management.

Law

More and more legislation is being passed to ensure safer working conditions. New laws and standards are made due to the actions of individuals, courts and influence groups.

Inflation

Material shortage brought about by the expansion of businesses has contributed to inflationary trends. These shortages, combined with increased costs of labour, energy and insurance, have caused both capital and replacement equipment costs to increase. Managers realised that the costs of replacing damaged equipment due to accidents is more expensive than normal depreciation of equipment and that costs can be reduced if equipment can be made to last longer than its expected life.

Medical research

Medical research is increasingly focusing attention on physical and health hazards in the workplace. The research is helping to define limits on exposure in cases where problems can be avoided by limiting the amount or duration of exposure. More importantly, research is identifying substances and by-products that have irreversible effects.

Energy

Energy resources have become more critical in a large part of the world. Where energy is limited, and even where it is not, cost is rising rapidly. Energy loss affects the supply of equipment and material needed to make the products or provide the service, effectively increasing production costs.

All these factors are affecting society in general. Workers are demanding a safer working environment to be provided by management. Public awareness of individual rights has put pressure on management to emphasise safety. Managers also want to avoid big payoffs in compensations or claims by workers or fines by authorities in breach of safety. These safety activism factors indirectly are changing the attitude of management and workers towards safety.

2.3.3 Evolution of Managing Safety

The introduction of the safety activism factors as discussed in Section 2.3.2 brought tremendous changes towards safety, with its management evolving from the infamous 'sweat shops' of the early 1900s through the treatment of safety strictly as merely injury prevention up to loss control as an integrated management responsibility. Several authors including Bird et al (1985), Denton (1982), Booth et al (1995) Cox et al (1996) and Fitts (1996) have discussed how the management concept regarding safety has changed over time.

According to Booth et al (1995), traditional management has been directed at prevention of repetitious accidents that occurred, derived from the investigation analysis (Figure 2.11). Booth argues that traditional safety management has concentrated on reactive prevention because it is easier to deal with. Proactive safety measures require time and resources which are always readily available.

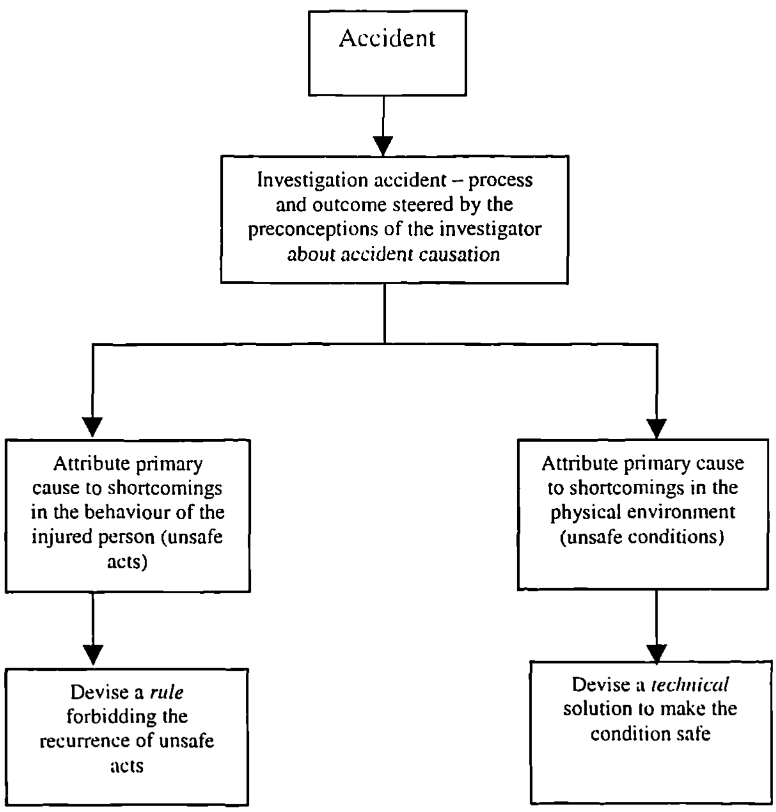


Figure 2.11 – The traditional approach to the management of safety (Booth et al 1995)

Bird et al claimed that the industrial revolution brought about extensive use of power machinery and with it a whole new group of potential accident risks. Machines were unguarded, people were unskilled and untrained, working times were longer which increased exposure to accident potential; facilities for emergency core were extremely inadequate and medical help was seldom available. As a result the fatality record was high. Corrective measures were primarily engineering-orientated and at this stage a transition began to take place in management thinking. Denton (1982) states that along with the early laws stressing the monitoring of unsafe conditions, there was the influence of Frederick Taylor whose studies had strong implications on industry. Taylor’s most important contribution to management was the use of scientific fact-finding and a concern for efficient material handling so that a more logical and rational workplace could be established. Taylor's approach let managers consider the following:

- Job description - the concept that a job can be described on a piece of paper and a belief that anyone going into that job will do what the paper says - organisations do not change, people do;
- Standard of performance - the concept that minimum level of acceptable performance can be defined and used in appraisals; and
- Organisational charts - the concept that says organisation charts describes the authority networks, communication flow and powers.

Here safety was low on management's motivational scale. How would safety fit in the management school of thought? Bird et al (1985) reported that there was a conflict between different management thinking. For example, it was obvious that the scientific approach, which said that ‘everybody is alike - we can get behaviours we want through manipulation’, was overshadowed by the human relation school of thought, which said that 'everybody is alike - we can get the behaviours we want by making the workers happy’. Later in the 1970s, the contingency school of management thinking emerged which said that 'everybody' is different'. In conclusion both Denton and Bird et al agreed that management style and how to deal with workers must be contingent upon the situation, the workers and their needs. It was also at this time that Frank and Lillian Gilbreth stressed the need for design improvements of equipment and handling procedures and influenced production and safety by providing a logical means of performing work. In the late 1970s and 1980s, the situational leadership style became popular among managers. This was based on the amount of directions (task behaviour) and the amount of sociotechnical support (relational behaviour) a leader must provide given the situation and the level of maturity of the group. The industry, with its root in scientific management, started to become concerned with upgrading machine design and physical working conditions. When unsafe conditions were improved, dramatic accident reduction often resulted.

Denton suggested that in order to analyse and implement control over working conditions, technically orientated personnel were hired or transferred to assume safety responsibilities. The law had a heavy influence on the safety management and ensured that a safe and healthy workplace was provided for the workers. Its emphasis on the control of workplace conditions through specification standards is easily seen.
Cox et al in 1996 developed a generic safety management model as depicted in Figure 2.12, which integrated the following:

- basic system concepts of control and particularly purposeful control through planning and effective decision making and monitoring;
- goal setting and its centrality in current approaches to safety legislation;
- effective task implementation and completion;
- the need to establish a good safety culture which incorporates the characteristic of good safety performance;
- the implementation of a Person-Job-Organisation (P-J-O) approach which requires the organisation to define technical standards, safe systems of work and competencies of its employees; and
- finally the assurance that all P-J-O systems are in line with quality principles.

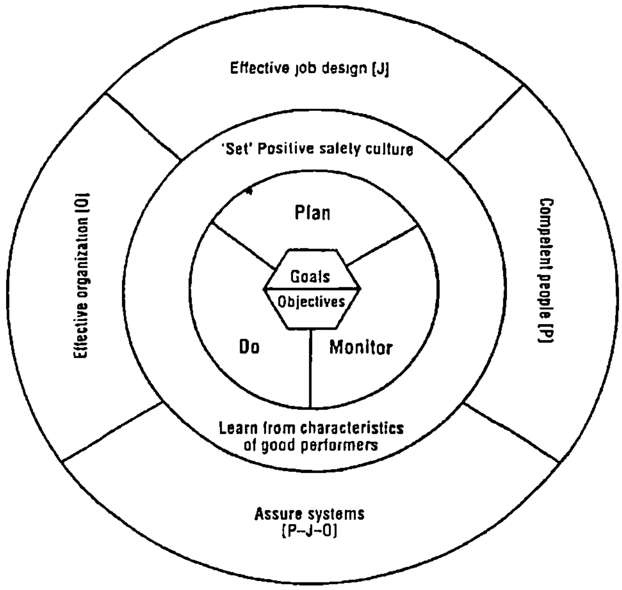


Figure 2.12 – Generic safety management model (Cox et al 1996)

Cox et al emphasise that the primary aim of safety management is to be able to intervene in the accident causation process and break the causation chain. The strategic approach to management of safety demands two complementary processes:

a) Management has to decide where safety fits in relation to the primary purpose and goals of their organisation.
b) They have to decide on the goals and objectives for safety management. At this stage, they may also consider how safety goals can be integrated into all areas of business activity.

Fitts (1996) states that a good safety management framework should have the following:

a) A properly structured safety system that will unite all of a company's safety programmes, policies and procedures into one comprehensive system that functions as a whole. The structure should define the roles and responsibilities of all team members for the system's organisation.
b) People that function with the system.
c) Understanding of the system through safety orientations and subsequent safety training in the policies, procedures and processes that comprise the system.
d) Channels for personnel to make recommendations for safety improvements.

e) Safety communications that assist in maintaining the safety system interest and enthusiasm as well as augmenting the knowledge.
f) Management that is responsible for instigating the safety management system; supervisors are responsible for system implementation and everyone is responsible for participating in the system.
g) Methods for measuring the existence and effectiveness of the safety system including observations, interviews and documentation.

Through this brief description of safety management evolution, it is clear that safety is still going to change for the better. If initial approaches tended to be reactive, current interest in safety is more proactive. Many studies have pointed out the advantages of the proactive approach and these will be discussed in detail in Section 3.3.3. Safety must be integrated into management as part of the overall business strategy.

The discussions of the evolution of managing safety have demonstrated how safety is slowly but surely becoming more important in the industry. More studies and research are focusing on safety to achieve better safety performance records. The following section will highlight the way forward to achieve this aim.

2.4 THE WAY FORWARD

2.4.1 Behavioural Safety Management

Accident investigations are paying more attention to the behaviour of people at risk; the behaviour of organisations seeking to control risks and the behaviour of managers directly involved. Hubler (1995) stated that the 1980s saw the development of behaviour-based safety programmes which were built on the fundamental principal of accident prevention established by Heinrich. Cameroon et al (1999) agreed with Hubler saying that the evolution of safety management had produced a human factor era. These human factors identified the need to focus on the operative level as well as the management level. The principle was that worker behaviours are a function of the attitude and sense of belonging to informal work groups. Workers' reactions to changes are tempered by the meaning the change has to individual workers. It also showed that consistent observation plus positive intervention are critical to changing employee behaviour and increasing productivity. Behaviour based safety management is very similar to the continuous process improvement concept and techniques that are a major component of TQM (Total Quality Management). Maloney et al (1999) emphasised that the critical dimension of behaviour-based safety management is employees' involvement.

Hubler (1995) defined behaviours as demonstrated actions which directly reflect an individual's attitude and knowledge about working safely. A person behaves in a certain manner because of the anticipated consequences he or she may receive upon completing a job. Some people exhibit behaviours to produce pleasant consequences so as to earn positive rewards. Other individuals exhibit behaviours in order to avoid unpleasant consequences or negative punishment.

Vassie (1998) identified the following equation based upon the areas of control:

Safety = {physical control + procedural control} x human factor.

Both the physical controls and procedural controls are seen as separate, independent factors which are additive in increasing the level of safety. On the other hand, the human factors are seen as independently influencing the effectiveness of both physical and procedural control. Wagenaar et al (1992) highlighted six ways to improve safety levels through human behaviour as follows:

- do not induce safe behaviour, but make the system foolproof;
- tell those involved what to do;
- reward and punish;
- increase motivation and awareness;
- select smarter personnel; and
- change the environment.

Though Wagenaar's six ways mentioned above are very strict, this approach of behaviour modification (the use of positive reinforcement) is not new. The basic process involves systematically reinforcing positive behaviour to eliminate unwanted behaviour. The concept of behaviour modification is based on a simple formula developed by Peterson in 1980 (1996):

$$B = \int(C)$$

where B is the person's behaviour, is a function of the consequences of past behaviour, C. Both Peterson (1996) and Hubler (1995) agreed that if a person does something as a result of which something pleasurable happens, he or she will be more likely to repeat it. Likewise, if something painful occurs as a result of an action, he or she will be less likely to repeat it the next time.

Ramsey et al (1986) describe a classification system for unsafe worker behaviour which can be used to provide a means of systematically categorising the behavioural activities that potentially precede an accident. Ramsey's activities are:

- those related to worker;
- those related to tools; and
- those related to equipment.

The above discussions focus on behaviour as a prerequisite to improving employees' attitude towards working safely and indirectly creating the motivation to actively care for others. Recognising and accepting these values will lead to a positive safety culture. When a strong safety culture exists, safety will always be the number one priority in all aspects of the work. The following review concentrates on the importance of safety culture.

2.4.2 Safety Culture

Glendon et al (1995) stated that effective safety management is both functional (involving management control, monitoring, executive and communication sub-systems) and human (involving leadership, political and safety culture sub-systems paramount to safety culture). The concept of safety culture emerged from earlier ideas of organisational climate, organisational culture and safety climate. He described safety culture as the embodiment of a set of principles, which loosely defines what an organisation is like in terms of health and safety.

According to Booth et al (1995), the term safety culture was introduced to the nuclear safety debate by the International Nuclear Safety Advisory Group of International Automatic Energy Agency (IAEA) in their analysis of the Chernobyl disaster. IAEA defines the safety culture of an organisation as the product of individual and group values, attitude, competencies and patterns of behaviour that determined the commitment to, and the style and proficiency of an organisation's health and safety programmes. Overall safety culture can be described as a set of beliefs, norms, attitudes and social technical practices that are concerned with minimising the exposure of individuals, within and beyond an organisation, to conditions considered dangerous or injurious.

In this approach, safety is looked into from the cultured point of view - complex, shared characteristics of a group dynamic relating to a system (e.g. group, community, race, nation, religion) which include beliefs, values, attitudes, opinions and motivations. Glendon et al (1995) pointed out that building a safety culture on so. many diversities is not an easy task. But it had been proven that organisations with good safety cultures have employees with positive patterns of attitude towards safety practice. These organisations have mechanisms in place to gather safety-related information, measure safety performance and bring people together to learn how to work more safely. Ostrom et al (1993) looked at the employees' perceptions of safety culture as follows:

- management attitudes towards safety;
- perceived level of risk;
- effects of work pace;
- management actions towards safety;
- status of safety adviser and safety committee;
- importance of health and safety training; and
- social status of safety and promotion.

Characteristics of safety culture

Safety culture involves the participation of everyone in the organisation. If on site, it involves everybody from the project manager to the general worker. In order to cultivate the positive beliefs, practices, norms and attitudes among all in the organisation, it is important to know what the characteristics of safety culture are. Booth et al (1995) listed the characteristics of safety culture as follows:

a) The many separate practices interact to give added effect and, in particular, all the people involved share similar perceptions and adopt the same positive attitudes to safety – a collective commitment.

b) The synergy of a positive safety culture is mirrored by negative synergy of an organisation with poor safety culture. Here, the commitment to safety of some individuals is strangled by the cynicism of others. The whole is less than the sum of the parts.

c) The dominant themes for safety culture are:
   - the crucial importance of leadership and the commitment of all chief executives;
   - the safety role of line management;
   - the involvement of all employees;
   - openness of communication; and
   - demonstration of care and concern for all those affected by the business.

Indicators of safety culture

After understanding the characteristics of safety culture, it necessary to find out the indicators of safety culture. Glendon et al (1995) quoted studies in the US nuclear industry that identified four critical indicators of safety culture as:

- effective *communication*, leading to commonly understood goals and means to achieve them at all levels;
- good organisational *learning*, whereby organisations are able to identify and respond appropriately to change;
- organisational *focus* upon health and safety – essentially how much time and attention is paid to health and safety issues;
- *external* factors, including the financial health of the organisation, the prevailing economic climate and impact of regulation and how well these are managed.

Measurement of safety culture

Safety culture is measured by surveying the workforce's attitudes. This means that safety culture within an organisation is closely linked to attitudes in respect to safety. There are three major elements as stated by Glendon et al (1995) in respect of safety attitude:

- organisational rule – perception of others; attitude in particular those of work mates, supervisors, higher management and safety representatives;
- safety object of attitude – both passive e.g. checking equipment, wearing appropriate PPE, housekeeping; and active, e.g. finding out results of safety inspections, making suggestions, seeking safety information; and
- behaviour in respect of safety.

To implement changes in any culture may be faced with strong resistance. The same applies in any organisation. This change may be perceived as a threat by many within the organisation – resulting in resistance to proposed changes. Glendon (1995) described a holistic approach that is required to change safety culture, involving:

- sustained management commitment;
- sound safety policy;
- visible management support;
- allocation of sufficient resources;
- use of appropriate safety management techniques;
- continuous motivation of all staff;
- safety training provision;
- fostering a 'no blame culture';
- organisational learning; and
- persistence of purposes.

The above discussion concluded that safety culture of an organisation could be described as ideas and beliefs that all members of the organisation share about risk, accidents and incidents. This positive safety culture implies that all the people involved share similar perceptions and adopt the same positive attitudes towards safety. The active role of management and the involvement of all employees as key players in safety culture are important. It cannot be denied that organisations may face resistance to changes at the initial stage. But it is important to cultivate this safety culture, a sub-set of the overall organisational culture, because it is the key predictor to safety performance as supported by an extensive research programme carried out by the US Nuclear regulatory Commission (Booth et al 1995). The best health and safety performance can only be achieved when everyone including management and employees participates in the management of safety.

2.5 SUMMARY

1. Looking at the causes of accidents will help to understand why accidents/incidents keep happening. Very few accidents are associated with a single cause, particularly in large organisations and complex technologies. In fact many of these accidents are caused by many distinct causative factors, each one necessary but not sufficient to cause a final breakdown. For example, safety violation may often occur because of factors that essentially lie outside the individual's control such as overtime pressure, lack of appropriate equipment or inadequate training. Measures based solely on the traditional view of error are often only a palliative as they focus primarily on symptoms rather than underlying causes.

2. The legislation has changed over the years with more emphasis on safety at work. Still today the rules and regulations are being improved to make the working environment safe. Besides the effect of laws, many safety activism factors also influence the decision of modern managers regarding health and safety such as the active role of the trade unions, consumerism and the legal battle by accident/incident victims. All these factors are forcing modern managers to change their attitude towards safety. It is clear that safety is going to be better. Managers are adopting proactive approaches towards safety instead of the conventional reactive ones.

3. Widening the understanding of behaviour increases insight into possible targets for improvements, for example better planning, more effective job design, or more comfortable personal protection. Human behaviour influence on safety performance is enormous. Therefore this root problem must be managed effectively.

4. Today, the changes in safety management have opened a new outlook toward safety. It is no longer being treated as secondary in the business context rather it is treated as a culture. More emphasis is being put on ensuring everyone understands the importance of safety and changing the attitude and behaviour is the hardest task. Safety is not only the manager's responsibility` but everyone must play a part.

CHAPTER 3

SAFETY PERFORMANCE IN CONSTRUCTION

3.1 INTRODUCTION

The problem of safety performance has existed since the very beginning of organised attempts to control accidents and their consequences. The level of safety performance within an organisation reflects the loss that organisation will face. This loss may be due to either an accident or incident resulting in injury or property damage each time it occurs. Although the loss is not just monetary, the biggest expense is that of human life and because safety involves human life, it is therefore important for organisations to place specific emphasis on maximising safety.

The construction industry too needs to have a different outlook on safety. Safety must have equal status to other primary business priorities within construction. Young (1996) states that accident prevention forms good business practice in that a safe operation is usually an efficient one. In order to reduce the accident or incident level and therefore cut losses, it is important to ensure that safe working practice is being observed. The only way of knowing if safety really exists is to measure it and as the saying goes 'if you don't keep score, you are only practising'. Measurement is a pre-requisite to identifying the factors that need control and contribute to accident potential. The current reactive approach adopted in most construction organisations does not reveal either how safe a site is or what the safety culture is. Merely relying on post-accident data will not reveal sufficient information in order to improve the safety level.

This chapter discusses the scenario of safety performance within the construction industry. The first part looks into the drivers and barriers of safety performance followed by a discussion on why safety performance measurement is essential.

3.2 SCENARIO OF SAFETY PERFORMANCE IN CONSTRUCTION

3.2.1 Drivers to Improve Safety Performance

3.2.1.1 Construction industry safety record

In the UK, the most reliable statistics are those published by the Health and Safety Executive (HSE). These statistics are used for benchmarking of safety in all industries. The HSE's annual safety statistics show that the construction industry safety performance record is worse than that of most other industries and indeed that construction has never been a champion in safety. Figure *3.1, 3.2 and 3.3 show the* fatality record, the non-fatal injury record and over 3-day injury rate respectively for construction compared to other industries for the years 1989/90 to 1998/99 (HSE 1999).

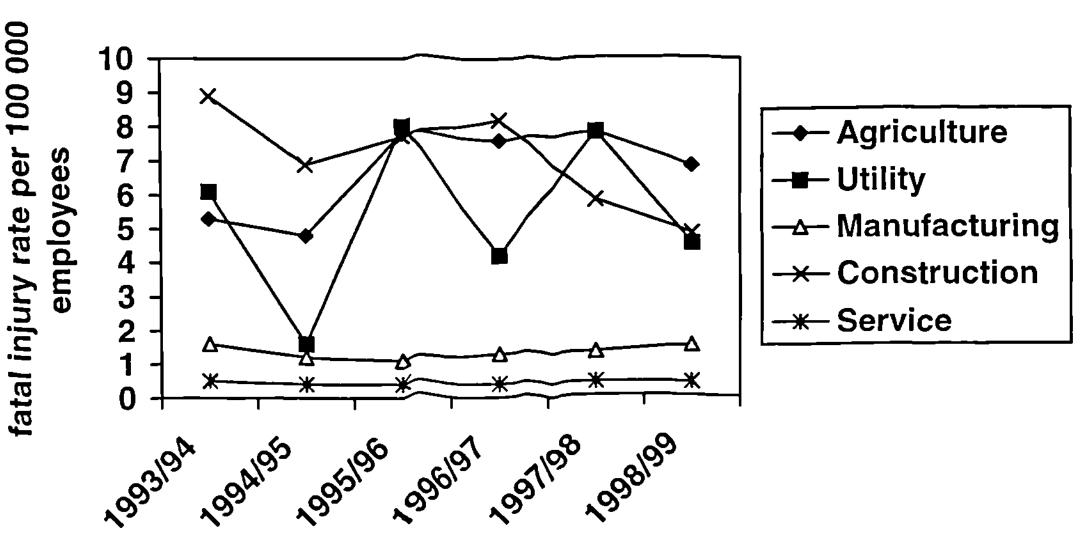


Figure 3.1 – Fatal injury rate for employees within the industrial sector 1994/95 – 1998/99 (estimated figures)(HSE 1999)

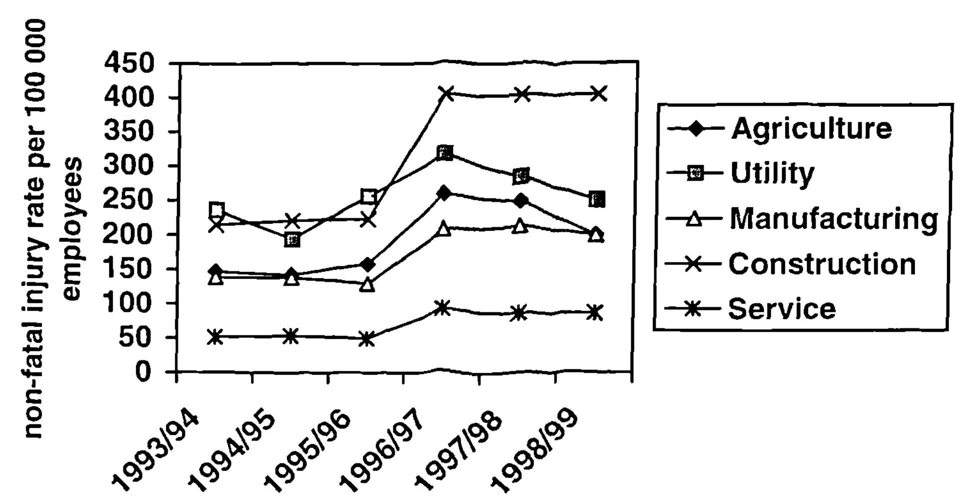


Figure 3.2 – Non-fatal injury rate for employees within the industrial sector 1994/95 – 1998/99 (estimated figures) (HSE 1999)

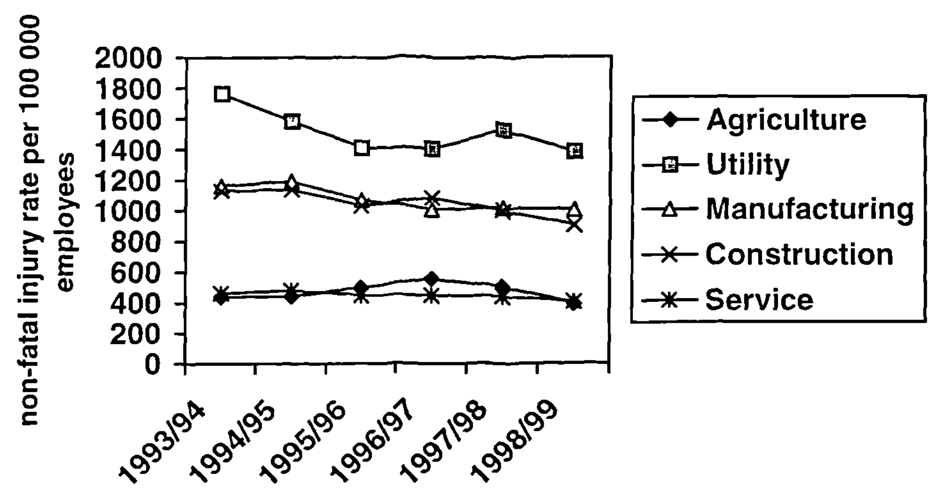


Figure 3.3 – Over 3-day injury rate for employees within the industrial sector 1994/95 – 1998/99 (estimated figures) (HSE 1999)

The 1993 HSE annual report states that the fatal injury rate for employees within construction is expected to fall to the lowest since 1991/92 while the non-fatal major injury rate is predicted to increase by 4% to 399.2 per 100 000: - a level similar to that for 1996/97. From figure 3.3, the over 3-day injury rate is seen as decreasing for the construction industry. However although the long-term trend is downward, the accident rate is still significantly above that of the manufacturing industry and other sectors. Anderson (1998) confirms that recent extensive research into working conditions on a European scale concludes that construction and agriculture remain the sectors of employment where workers are most exposed to traditional physical risks.

3.2.1.2 Reactive data is not a reliable measure of safety

Many authors agree that the general approach to safety within the construction industry as a whole is one that is primarily 'reactive' (Jacobs (1970), Ramsey (1986), Whittington et al (1992), Lindsay (1992) and Smith et al (1996)). Typically, organisations exhibiting this characteristic show a combination of the following features:

- a mainly technical or hardware approach to safety;
- a 'rule and regulation' safety culture;
- a traditional safety view of human performance known as the 'blame culture'- accidents happen because the individual concerned was careless or did not follow the rules; and
- an emphasis on short term solutions to safety problems rather than an attempt to identify more deep-rooted organisational failures (Whittington et al 1992).

Many forms of safety performance indicators have been developed. Laufer et al (1986) classified safety performance measures into post -accident and pre-accident performance as in Table 3.1.

Table 3.1 – Classification of safety performance measures (Laufer et al 1986)

Time of measurement	Criterion of safety effectiveness	Data collection method
Post –accident	• Frequency of undesirable events	• Secondary data
	• Severity of undesirable events	• Secondary data
Pre-accident	• Undesirable practices	• Observation • Questionnaires • Interviews

Smith et al (1996) and Laufer et al (1986) agree that reactive measures are post-accident measures looking at injury, ill health and incidents. The reactive measures tend to be limited to factual data about the victim such as age, gender, occupation and thus lack other vital information such as environmental conditions, task factors and behavioural factors. The report only includes activities which were directly and immediately involved in the accident and the failure to look towards understanding the factors thus limits the suitability. Even with a low reported accident rate, over a period of time, there is no guarantee that the site will be free of hazards. The authors claim that in such cases, statistics can be an unreliable and deceptive indicator of safety performance and such approaches do not evaluate project level safety performance effectively. Indeed they contribute little towards suggesting steps to prevent recurrence, and any learning from an accident becomes an expensive experience (physical and psychological damage).

Reactive measures rely on both the reporting of accidents and the efficiency of reporting. Historically there has always been a low level of reporting of accidents by employers. However over the period of six years since 1989/90, saw a substantial increase in these levels for most industries. Overall, the level of reporting has improved from 34% in *1989/90* to *43% in 1996/97 while for construction industry, the* increase has been from 38% in 1989/90 to 55% in 1996/97 (HSE 1999). However although the figures show an increase, the level of reporting must still be improved.

Reactive measures also rely on effective reporting, for without proper training a report may yield poor results due to the missing of important data, difficulty in gathering data and in consistency of data. Additionally there is the problem of difference in definition of reporting. A study performed by Clarke in 1992, across twelve European countries, concluded that there are different ways of reporting accidents. For example in the case of fatal accidents, Table 3.2 shows five different ways of interpreting it as applied across the twelve countries.

Table 3.2- Different definitions of fatal accidents by 12 European countries (Clarke 1992)

Fatal accident definition	Countries
Same day	Spain, Portugal
Up to 30 days	Netherlands
Up to 1 year	UK
No time limit	Denmark, Belgium, Germany, Greece, Ireland, Italy, Luxembourg

Not all countries record the date of death on the accident form. Definitions for recording accidents as fatal range from those that cause death on the same day as the accidents (Spain and Portugal) to no specified time limit. However, in Spain, the statistics may later be amended to include subsequent deaths. The shorter the length of time allowed designating an accident as fatal, the greater the likelihood of missing some 'delayed deaths' in the fatal accident figures.

In conclusion, using reactive measures based only on measuring and comparing the frequency of accident occurrence does not seem fruitful. It is not only difficult to interpret due to the statistical 'flakiness' which governs the occurrence of rare events but also, because the expected frequency of occurrence is the product of both the risk or probability of occurrence and the magnitude or amount of human exposure.

3.2.2.3 Good reasons to improve safety performance on construction sites

Every accident is a reflection of the quality of management. This is emphasised by Kletz (1993) in official reports such as on Piper Alpha and the King's Cross Underground Station fire. The competence of management was criticised rather than their motives. A study by Liska (1993) showed that 90% of construction deaths were preventable and 70% of cases could save lives by positive actions of management. The construction industry is becoming more aware how important it is to have an effective safety programme. There are several contributing factors including:

- responsibility;
- economic reasons;
- impact of safety on overall performance;

- contractor's performance;
- control of accident causes; and
- reporting of safety level.

Responsibility

Safety is everyone's responsibility. It is a moral and legal obligation of employers to provide a safe working place and of employees to work safely. Section 3 of the Health and Safety at Work Act 1974 places obligation on employees to undertake work in a manner which will not cause risks to other persons. Ridley (1994) described the employer's duty of care to employees as covering the following areas:

- safe system of work;
- a safe place of work;
- plant and machinery that is safe to use;
- competent supervision and/or suitable training; and
- care in the selection of fellow employees.

Employers too will have to provide a safe working environment and manage safety like any other company function. On a site it is also important to assign safety responsibility to all levels of management and workers.

Economic reasons

All injuries will have an adverse impact on the running of a construction project. Realising the magnitude of the problem, in 1979, the Business Roundtable (BR) commissioned a series of studies to examine the costs of injuries in the construction industry. The purpose of this study as reported by BR (1982) was to draw attention to the true costs of accidents in the industry in hope for better preventive measures. The study agreed that the costs of accidents include both direct and indirect costs.

Many authors have discussed both these aspects including Hinze (1991), Everett et al (1996), Bentil (1990) and Clarke (1999). The general definition of direct costs are those that are most visible including insurable costs which can be easily quantified (this includes doctors fees, hospital fees and insurance premiums). On the other hand, the indirect costs are far more elusive to identification and particularly quantification.

Hinze (1991) claimed the indirect costs (excluding claims and material damage costs) to be more than 1.67 times the direct costs of accidents.

Impact of safety performance on overall project performance

Clients and contractors have become more aware of the impact of safety performance on the overall project performance. Rodriguez (1996) showed that projects that were consistently behind schedule and over budget experienced a greater occurrence of recordable accidents. Statistically significant differences between safety performance levels were evident primarily during the middle and end of construction for projects behind schedule; projects that were over budget showed statistically significant poorer safety rates towards the end of the project.

Contractor's performance

Smith et al (1996) and Wilson et al (2000) agree that there is an adverse effect on a contractor's reputation and unfavourable image for the client when the project suffers high accident rates. It is important for a contractor to have a good image in order to enable them to tender for the next project. Wilson (2000) claimed that larger construction companies are better organised in terms of safety. It is important for large and small companies to uphold their reputation as well as maintain safety records. In order to achieve this, they must be better prepared to manage safety aspects of a project.

Control of accident causes

Laufer et al (1986) and Smith (1996) agree that safety performance measurement enables behaviours and conditions to be identified that have the greatest potential in contributing to an accident. It also forms a basis to predict future accident problems and enables management to control the causes of accidents on site. Tarrants (1980) agrees that the measurement approach essentially allows the management to establish long-term accident control. These measurement techniques provide continuous information concerning changes in the safety state within an organisation in operation. A valid and reliable measure of these changes permits evaluation of the effectiveness of accident prevention efforts over time.

Report safety level

Implementing safety performance measurement provides a description of relative levels of safety and a continuous report of fluctuations within an organisation. Smith et al (1996) agreed that the statistical data could provide a convenient mechanism for comparison and determining the relative risk of one company or one site with respect to another and form a basis for trend comparison. Safety performance measurement enables the management to order and quantify certain events and ultimately use the results as a basis for the control and prediction of actual performance. Smith continues to add that continuous reporting of safety performance is an essential prerequisite for control and prediction for future events.

3.3.1.4 Importance of measuring performance

The importance of measurement is reflected in Druker's statement that 'what gets measured gets done' (Hubler 1995). Measurement has been the principle indicator and stimulus of progress in all fields of scientific endeavour and indeed forms the backbone to any scientific approach towards problem definition and solution. The essential prerequisite for control and prediction for future events is measurement. which is defined by Tarrants (1980) as the 'process of assigning numerals to objects according to rules'

Tarrants continues to report that measurement is essentially a decision-making activity, and its usefulness must be evaluated in terms of its ability to provide information that will improve both accuracy and validity in forming a decision. He adds that measurement connects three parts of knowledge – the mathematical, the conceptual and the practical. Primarily, measurement is a descriptive process. It allows one to quantify, order and quantify certain events and ultimately use the results as a basis for the control of actual performance.

Laufer et al (1986) divided safety performance measurement system into output measurement and process measurement. Output measurement can be divided into four subdivisions:

Lost day cases	absence from work
Doctor's cases	non lost workday case that is attended by a doctor
First-aid cases	non lost workday case that requires only first-aid
Non-injury cases	accident not resulting in personal injury but including property damage or productivity disruption

Measuring performance against predetermined standards can reveal when and where actions are needed to improve performance. A key question concerning measurement is whether it should be expressed in terms of behaviour, tasks, traits or organisation outcomes? Should criteria be qualitative or quantitative? Measurements that are quantitative in nature (e.g. number of safety audits being carried out) are easy to measure when compared to the qualitative measures (e.g. measuring safety attitude of workers). Tarrants claims that, whatever measurement approach is chosen, it must be sensitive to the fundamental behaviour and conditional malfunctions that may at any time contribute to an accident loss problem. The safety performance measurement technique chosen must be able to provide as a basis for:

a) causal factor detection;
b) trend comparison;
c) predicting future accident problems;
d) evaluating accident prevention programme effectiveness;
e) making decisions regarding the allocation of accident prevention resources;
f) assessing accident costs; and
g) quantifying probable risk of injury or other losses.

The technique must also be able to:

a) locate and identify problem areas;
b) describe the current safety state of an organisation; and
c) and establish long term accident control.

3.2.2 Barriers to Safety Performance Improvement

3.2.2.1 Nature of the industry

The construction industry generally has a rough and tough image and the many variables which exist make it one of the most difficult industries in terms of health and safety. Clients can range from a shopkeeper to a government department, sites can be on a green field or a former factory, and the type of work can vary from small roof repair to the construction of a power station. Grubb et al (1999) added that the changing nature of both the workforce and the work environment within the construction industry provides a unique challenge to health and safety. For example, there may be both different labourers and companies interacting on a given construction project, with worksites and co-workers varying from day to day. As a consequence, a diverse set of potential hazards arises. In addition, the construction industry relies heavily upon part-time and temporary workers as well as a varied work schedule, and there is also a seasonal aspect to the work.

These arguments are often used to explain the problems facing the construction industry. However, Brown (1996) looked into these common analogies about the industry and put forward arguments seeking to dispel the myth that construction is a high-risk industry. Table 3.3 summarises Brown's views on the difference between the facts and myths. Here Brown sought to challenge the conventional view regarding the construction industry. He states that the industry just using these myths as excuses for its poor safety performance when compared to other industries.

Table 3.3 – Difference between the facts and myth about the construction industry as claimed by Brown (1996)

Myths	Facts
Transient workforce – difficult to keep the same safety indoctrinated and trained workers for long periods.	The same core group of workers mainly dominates the industry – these groups had more safety inductions than they can count.
Each type of project has unique characteristics such as the design, size etc.	The construction process has not changed appreciably over the years and the activities involved are still the same. It could be argued that the work is static with regard to the way in which the work is programmed and implemented - just the same as the other industries.
Due to the ever-changing nature of the industry, hazards can vary from one project to another. The use of a safety programme can be ineffective.	Construction activities do not utilise or need the same sophisticated methods of fair safe guarding or emergency shutdown systems, because hazards are relatively low in construction compared to other industries. The principal direct causes of injury in construction have not changed for many years e.g. falling from a height, struck by machine or falling objects and others.
The changing nature of the workforce involves different labourers and companies interacting at different levels on a project. It is therefore difficult to control.	Construction is not the sector that utilises the services of numerous trades, working to tight deadlines and schedules.

Whether its is myth or fact, it cannot be denied that the nature of the industry is highly labour-intensive and task-focussed. Projects are nearly all different and the workforce is in constant flux moving from one site to another. This mobility will force the workforce to adapt to the safety requirements from different management. Some will be strict while others may be indulgent with the safety rules.

3.2.2.2 Shortcomings in the present level of safety training and education

Even though some safety skills and knowledge can be applied using common sense, there is no substitute for targeted education and training, including the specification and testing of basic competence (Anderson 1992). It is important for workers to have knowledge of construction safety which is essential to their job performance. The education and training of the professionals is also important because of their pivotal role in ensuring health and safety of construction site personnel.

The requirements for training in matter of health and safety are well established in legislation. The Management of Health and Safety at Work Regulation (MHSWR) 1992 and the Health and Safety at Work Act (HSWA) 1974 emphasises that it is the duty of the employers to provide adequate training as reasonable practical with regard to health and safety to all employees. Training can be held publicly or in-house. The Construction Training Board (CITB) provides the education and training necessary for construction. So generally the industry has enough legislation and training available to conduct training.

The questions posed are to what extent are the various legislation and training programmes responding to this need? In a report by Sherrington (1997) on a survey conducted on 70 construction sites, it was found that 63% of operatives had not been consulted about health and safety training. The survey also pointed out that only 50% of the operatives had any health and safety training when they started on site. This indicates that there are untrained operatives that will be taken on board who will not only put themselves at risk but also jeopardise the safety of their colleagues. Hoare (1997) reported that many big contractors are instituting safety training programmes just to win contracts, and are struggling to demonstrate safety competence.

Anderson (1992) argues that in order to remove this barrier questions like how to conduct safety training, when it should be given, how it should be tested and how often it should be updated should be addressed.

3.2.2.3 General apathy and complacency towards health and safety issues

Project and construction managers are multi-displined individuals with a lot of responsibility. Managing, planning, cost, schedule, quality, labour relations, clients relations, procurement, contracts, etc are all the duty of the manager. Both Hopkin (1995) and Anderson (1998) argue that it is little wonder that with such a big responsibility and when the company experiences a long-term reduction in the number of accidents, individuals may have 'lost the fear' of the consequences of an accident. The importance of safety just becomes diluted if accidents are not occuring. Anderson and Hopkin agree with Lord Robens in a report of the UK Committee on health and safety at work report in 1972 that "the most important single reason for accidents at work is apathy'. Companies only react when accidents occur and everyone will be on their feet and being extra careful for a week or so. After a while things will be back to normal.

3.2.2.4 Lack of sufficient resource allocated to health and safety

There is still the macho belief that safety is for whimps. Thus there are still many companies that are merely paying lip service to the safety regulations or preparing inadequate safety plans. Therefore many still feel that putting safety as a priority as being sissy and investing in safety does not pay (Hislop 1999). Good health and safety performance undoubtedly comes at a price including time, expertise, devising implementation of a safe system and others. Changes can only occur when managers are committed to safety. However, changes can only be initiated by the directors of companies, who adequately fund and plan the future of construction safety management. This must involve construction clients, who bear the ultimate responsibility for the process that they are initiating and funding. The issue often raised is how many clients are willing to commit additional finance for safety?

3.2.2.5 Overemphasis at site level on meeting deadlines

Construction is task-oriented i.e. the objective is getting the work done on time. In other words the construction industry is a slave to time. Schedules must be followed and deadlines must be met to make the project financially successful. Usually the faster a contractor finishes the project the greater the profit. Delays may cause the contractors to be penalised. Speed of construction can be the nemesis of safety. Regrettably in these circumstances workers will sometime take short cuts to meet the target plan. Rushed workers make errors in judgement causing injury to themselves, other workers and the general public. Here productivity is very much at the expense of safety (Hopkin 1995). It has also been shown that injuries often occur when workers are under pressure.

3.2.2.6 Industry rightsizing

Hislop (1999) states that the construction industry is downsizing which result in the use of specialist-contractors in many trades. This will result in many operatives working for different companies on site at the same time. It is assumed that specialist-contractors have the requisite technical knowledge and skills to perform the work for which they are retained. The principal contractor expects specialist-contractors to perform their work competently and in compliance with the principal contractor's health and safety plan. Hislop argues that, although many specialist-contractors do understand the risk associated with the work and perform the work with regard for safety, there are many who fail to take appropriate steps to perform safely. He pointed out that many specialist-contractors fail to adequately control the hazards generated by their own work process or fail to consider that it is their responsibility to protect other workers in the vicinity. The action may be due either to ignorance or a misguided sense of urgency.

3.3 IMPLEMENTING PROACTIVE MEASURES TO IMPROVE SAFETY ON CONSTRUCTION SITES

Many studies and models have been developed based on this concept of unsafe behaviour and conditions including by authors such as Staley et al (1996) and Smith et al (1991). All these models agree that proactive, or pre-accident measures are the answer to producing better safety performance on site.

Both authors agree that most safety measures are post-mortem or 'after-the-fact' in nature and provide data which has little historical value. If the safety record is good, most managers will choose to reduce the emphasis on safety and conversely, management will give strong support following a severe or fatal accident. Waldram (1991) claims that a simple measure of performance in terms of accident frequency rate incidence is not a reliable guide to the safety performance as there is no correlation between such measurement and the work conditions, injury potential or the severity of injuries that have occurred. As a result, the reactive measures can give a misleading picture. Low reported accident rates, even over a period of years, is no guarantee that risks are being effectively controlled and nor will it ensure the absence of injuries or ill health in the future. This is true for organisations that have a low probability of accident occurrence but where major hazards are present. In such areas, the historical incidence of reported accidents could be an unreliable and deceptive indicator of safety performance.

Unlike reactive measures, proactive ones deal with data from current safety situations. Lindsay (1992) states that proactive measures provide essential feedback on performance before injury or incidents occur and involve compliance with performance standards and objectives - active participation of all levels of management. With proactive measures, appraisal is constantly carried out such that they are recommended as a sensitive and reliable indicator of safety performance. Chhokar et al (1984) added that reactive measures must be able to:

- identify all contributing factors;
- indicate positive steps that can be taken by both management and workers;
- identify loss-potential problems at the no-loss stage; and
- help predict, control and reduce accident losses.

In addition Anderson (1992) states that proactive safety performance is assured by providing the following:

- plant and equipment (hardware) which is ‘fit for the purpose’ of reducing risks from identified hazards as far as is reasonably practicable;
- systems and procedures (software) to operate and maintain that equipment in a satisfactory manner and to manage all associated activities; and
- people who are competent, through knowledge, skills and attitudes, to operate the plant and equipment and to implement the systems and procedures.

These are positive inputs of safety management, which are put in place to prevent the negative outputs (failures). A recent study by European Process Safety Centre (EPSC) concluded that performance indicators are also required for the positive inputs meaning that safety performance measurement has to cover the four areas: three that are essentially positive (plant and equipment, systems and procedures and people) and one that is essentially negative (failures) (EPSC 1996). This is illustrated in Figure 3.4. Continual improvements in safety management is about proactively expanding the positive inputs to reduce the negative outputs – that is, to reduce the total number of incidents which create harm and loss to people, environment and assets (Figure 3.5). This will enable the safety management system effort to improve continuously in effectiveness and efficiency, thereby controlling and reducing the risks of operations.

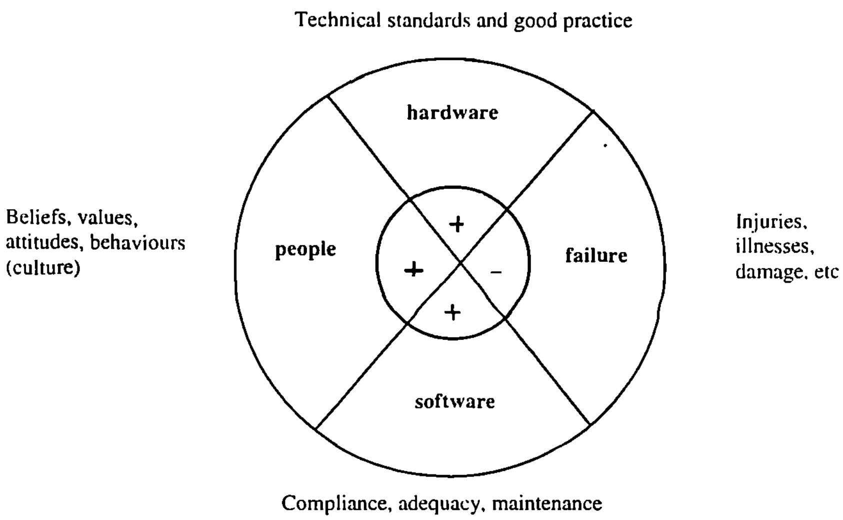
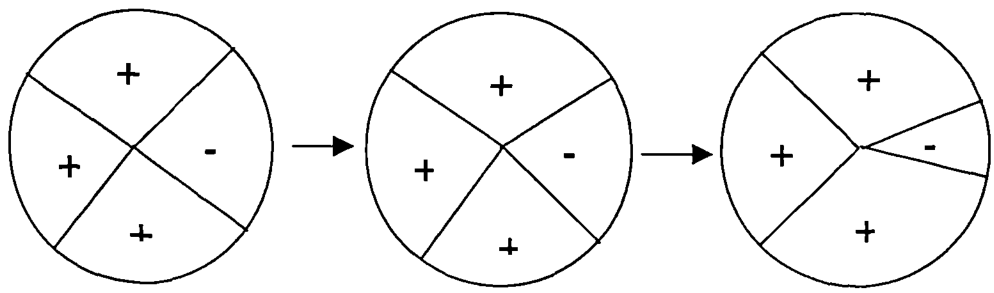


Figure 3.4 – Safety performance measurement – the areas to be covered (EPSC 1996)



Accentuate the positive to eliminate the negative

Figure 3.5 – Safety performance – continual improvement (EPSC 1996)

The study by EPSR (1996) and Linsdsay (1992) continues to add that the implementation of the inputs to safety management can be monitored by variety of approaches such as:

a) indirect monitoring where managers check on the quality and quantity of monitoring activities undertaken by their subordinates;
b) procedures to monitor whether it is weekly or monthly reports;
c) periodic examinations of documents to check those standards relating to the promotion of safety culture are encouraged;
d) systematic inspections of site, plant and equipment by supervisors, maintenance team and safety representative to encourage the continued effective operation of hardware controls;
e) environmental monitoring and health control measures to detect early signs of harm to health;
f) systematic direct observations of work and behaviour by first line supervisors to assess compliance with procedures, rules and systems – particularly when directly concerned with risk control; and
g) operation of audit system.

3.4 COLLATION OF EXISTING SAFETY PERFORMANCE MEASURES

3.4.1 Review of Existing Safety Measurement Tools

The literature reviews indicated a strong safety culture in the petrochemical engineering industry compared with that of the general construction industry. Du Pont, a world leader in safety, claimed that 96% of lost workday and restricted workday cases are caused by unsafe acts of people who created unsafe conditions (Hubler 1995). The overall construction industry is still looking at positive ways to change to a safer working environment with many researchers including Hinze et al (1996), Bentil (1990) and Staley et al (1996), trying to understand the causes of accidents. In general the objective of these studies of accident causation is to prevent accidents. These accident causation theories have gone through various changes based on the foundation of the domino theory. Over the years the domino theory has been updated with an emphasis on management as a primary cause in accidents.

Many factors help to activate the concern for safety such as trade unions, consumerism, technology and others. With the influence of safety activism factors, safety is becoming everyone's concern – not just the worker or individual. Safety is looking beyond accidents and more towards human behaviour and culture. Measurement will enable comparison and benchmark performance and track progress from time to time. Once the principle and the practice of measurement become the norm, this will transform motivations, attitudes and choices in every construction company.

The existing safety measurement presented in this chapter comes from extensive literature reviews and contact with industry. From the literature reviews, the author has identified at least thirty different measurement techniques, all of are in-house systems. Typically companies design their own safety manual and procedures. These safety assessments were mainly carried out within the petrochemical sector where safety is the highest priority. In addition a few assessments are presented that focused on the overall construction industry. A summary of existing safety performance approaches is presented in Table 3.4 while a detailed explanation of the assessment can be found in Appendix 3.1.

Table 3.4 – Existing safety performance assessment

Types of assessment	Authors	Year	Name of assessment
Safety audit	Magyar	1983	Performance rating
	Bond	1985	International Safety Rating System (ISRS)
	Waldram	1991	Elements Loss Prevention Management
	Cote B et al	1991	TOTAL
	Byrne	1996	Three levels of audits
	Hurst	1996	Process Safety Management (PRIMA)
	EPSC	1996	REALM
	EPSC	1996	Operating system
	HASTAM	1999	CHASE
Behavioural safety	Ramsey	1986	Classification of unsafe behaviour
	Duff R. et al	1993	Goal-setting & feedback technique
	Hubler	1995	Behaviour Accident Prevention Process (BAPP)
	Walker	1996	Behavioural safety approach
	EPSC	1996	Measurement of behaviour
Safety culture	Harrison	1996	Safety Culture Assessment Tool
	HSE	1997	HSE Climate Survey Tool
	Loughborough University	1999	Offshore Safety Climate Assessment Technique
Proactive safety management	Fitts	1994	Safety Management System (SMS)
	Aseidu	1996	Safety performance improvement
	Jaselskis	1996	Successful safety management
	Kvaener Construction	1998	Site Safety Performance System (SSPS)
	North Sea Chapter	1999	Safety Performance Indicator
	Cameroon	1999	Safety Performance Model
	NOHSC	1999	OHS Performance Measurement
Safety training	Hubler	1995	Safety Training Observation Programme (STOP)
Reactive measures	Laufer et al	1986	Safety performance measurement
	Haines et al	1991	Group Unified Accident Reporting Database (GUARD) reporting system
	Azambre	1991	Occupational Accident Analysis & Reporting System (OCCAR)
	Wagenaar	1997	TRIPOD
Benchmarking	CII/ECI	1999	Benchmarking initiatives

From the reviews of the existing safety performance measures in Table 3.4, the approaches can be grouped under six common headings as follows:

Safety performance approach	Frequency
Safety management/safety performance	11
Safety audit	7
Behavioural safety	4
Accident reporting	3
Safety culture/safety climate	3
Benchmarking	1
Safety training	1

Besides looking at the approaches adopted, the author also analysed the factors that were being measured. Figures 3.6 and 3.7 show all the factors that are being measured. Figure 3.6 looks at the proactive measures while Figure 3.7 examines the reactive measures with the unit representing the number of times the same constituent criteria is used. For example, looking at Figure 3.6, there are 49 different factors that are being measured. From these 49 factors, the highest frequency of factors used by companies is as follows:

Measuring factors	Frequency
Organisational/management control	13
Engineering control	8
Training	8
Behaviour/attitude	6
Design/planning	6
Housekeeping	6
Procedural control	5
Supervision	5

Among the 49 criteria identified can be a combination of a few elements. From the identification of measuring factors, the author will develop the SCMs for SPMT. Details of each SCM are discussed in Chapter 8 and Appendix 8.1.

Figure 3.7 illustrates twenty reactive measures. Most of the measuring factors (such as LTA, LTI, and fatalities) are measured as compliance to the legislation such as RIDDOR 95 and OSHA. Some systems may have additional measuring factors such as hazard measurement or workers compensation as part of the measurement process.

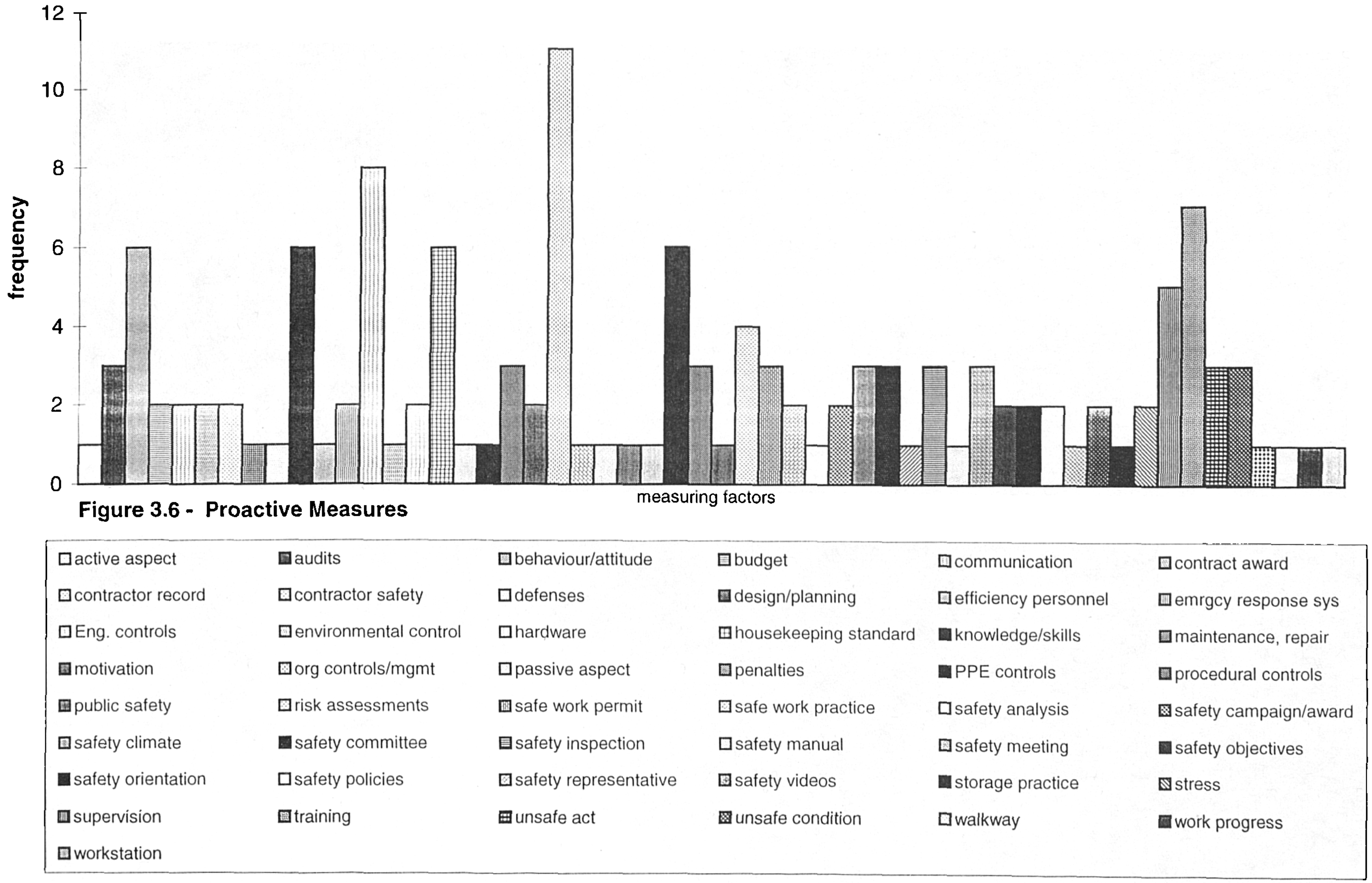


Figure 3.6 - Proactive Measures

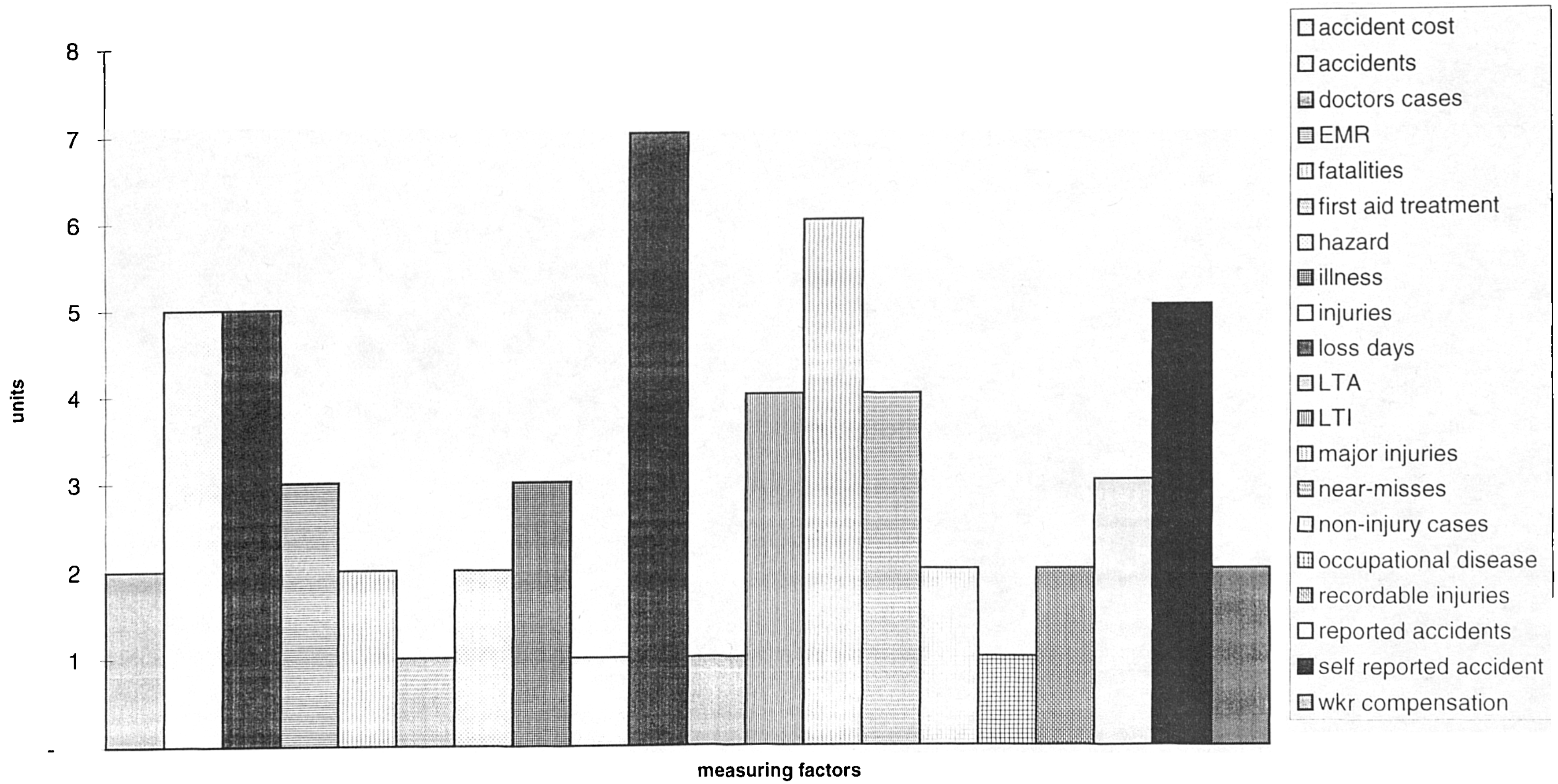


Fig 3.7 - Reactive Measures

3.4.2 Limitation of Existing Safety Performance Measures

From the discussion above, it can be concluded that each company will adopt or create their own measurement technique with each technique adopted being successful in its own way. Each approach adopted will only focus on specific aspects of safety in the organisations. The approach and methods of measurement are based on the organisation's preference and priority. The following are the drawbacks of some of the measurements:

Table 3.5 – Limitation of existing safety measurement approach

Measurement approach	Limitations
Safety audit	• Safety audit measures only the presence of the safety system. It does not measure the effectiveness of the system on site. After a safety audit has been carried out, an organisation may achieve excellent results on paper. But in practice accidents still keep happening.
Safety behaviour	• Measurement of safety behaviour depends on the observer's competency to recognise and measure the acceptable and unacceptable behaviour. • Individuals often feel threatened when they are being observed. • Measuring of unsafe behaviour is seen as a way of practising the blame culture.
Safety climate	• The safety climate measures are mostly carried out on petrochemical sites. Changes need to be made to adopt the approach for the whole construction industry. • The questions are not standard. They can be changed according to the needs of each site and organisation. An example of this approach is the HSE Safety Climate Tool (HSE 1997).
Accident reporting system	• Totally reactive

The limitations highlighted here are not intended to pinpoint the weaknesses of the existing system. Each safety measurement system adopted may well fulfil the company's aim and objective of safety. However, analysing the existing measurement systems will help in the development of SPMT. The author will review all the existing measurement systems when designing SPMT taking into consideration the positive points and limitations of each system.

3.4.3 Recommendation for a Single Standard Measurement Technique

Based on the above there exists a need to develop a single standard measurement technique for construction. By having a single measurement tool, the level of safety could be determined and a benchmark towards measuring safety performance could be formed. Jacobs (1970) agrees that the benefit of having a single measurement is that it must be able to evaluate the magnitude of changes over time or in comparative evaluation of two similar situations.

The development of a single measurement tool must be able to:

- reveal safety performance level;
- measure safety effectiveness that will enable identification of accident problems;
- provide continuous information concerning change in the safety state within an organisation;
- be sensitive to the fundamental behaviour and condition malfunctions;
- define where remedial actions are required; and
- continuously generate observable improvement in the way people work and thus will definitely lead to a good safety culture.

There is a necessity for a technique to measure safety performance in construction that will enhance the ability to predict and control accident losses. The generic technique must be able to be applied in the ever-changing construction industry. Other considerations are the relative cost involved in using it, the clarity of the system under study, the desired output, its compatibility with programmed activities and its meaningfulness to managers and those who will benefit from it.

What is important throughout the review is that many researchers agree that management involvement is essential. Factors such as safety training, orientation, safety awards, safety committee are also important. Simon (1991) et al suggest that communication is also important so as to encourage employees to suggest safety improvements and report near misses as well as unsafe conditions and practices. SPMT will be developed taking into consideration the accident causation theories, human error, the existing measurement techniques and other safety factors. In conclusion it is important that the development of SPMT must complement the existing measurement techniques.

3.5 MANAGING SAFETY IN CONSTRUCTION

Safety management in the construction industry is primarily designed to protect the health and safety of individual workers or members of the public. Whilst the risk of a major disaster, involving multiple injuries or fatalities exists on any project, the majority of accidents involve injury to an individual only. This reflects the pattern of exposure within construction industry where workers often operate alone or in small teams and are typically responsible for the organisation of their own work. It is not surprising that the responsibility of safety also falls on the individual.

Whittington et al (1992) reported that a contrast can be drawn with industries that are safety focussed such as the petrochemical or nuclear sector, which invariably involve the provision of PPE, relatively high levels of supervision and a rigid application of well-developed safety procedures. Whittington et al claimed that managing safety essentially involves four levels:

- the company policy level;
- project management level;
- site management level; and
- individual level.

Failure to incorporate safety at each level is the reason for accidents reoccurring. Besides the rough and tough nature of the industry, improper management of safety leads to poor safety records. For example Whittington et al claimed failure can occur at each of the four levels where failure at the first level will increase the probability of failures at the second level and so on.

a) At a company policy level – for example, inadequate training policy or poor methods of procurement.
b) At a project management level – for example, lack of planning, poor scheduling of work choice of inappropriate construction methods.

c) At a site management level – for example poor communication, lack of supervision or failure to adequately segregate work.
d) At an individual level – for example use of wrong equipment or failure to comply with an agreed method of work.

In their study about the style of management in construction, Whittington et al (1992) claim that construction companies are classified as 'pathological'. These organisations generally meet safety targets only as goals are set externally and more importantly, are seen to be controlled and enforced. Legislation provides the best chance to improve safety. Strict requirements for formal assessment, external auditing and adequate financial or other deterrents may be required to shift the construction companies towards the direction of the 'calculative' style of management. An organisation with 'calculative' style of management takes safety seriously but tends to focus on individuals and concrete technical issues. The biggest impulse for making improvements comes from evidences that such approaches really work and most large construction companies fall into this category. The best management style is the 'generic' style of management, which responds positively to suggestions and information on improvements of safety. The main drive for safety and safety improvements comes from inside the organisation while external agencies function more to aid, by providing independent assessment and auditing rather than control.

3.6 SUMMARY

1) The literature reviews reveal that the construction industry safety performance is low in comparison with other industries. The annual statistics published by HSE exhibit there is a big gap between construction and other sectors. These statistics highlight the importance to improve safety within construction.

2) Historical measures of safety performance based on post-accidents will not evaluate project level safety performance effectively. Reactive data will only report activities, which were directly involved with the accidents. These statistics will not reveal the true causes of accidents and thus makes it more difficult to improve the work performance.

3) Safety performance must also be able to support continuous process evaluations, assessing progress or change over time. The most important is being able to compare operational experience between two environments or areas of activities as a means of assessing relative performance. A time stream of such periodic data can provide an effective basis for regulating the application of remedial effort and control measures.

4) A new single standard measurement technique is needed for construction. This new measurement system should be devised to help prevent, control and reduce accident losses by identifying the following:
   - the contributing factors that affect safety performance on constructions sites;
   - positive steps that can be taken by both the management and the workers;
   - deviation in safety performance; and
   - loss-potential problems at no-loss stage.

5) Historically, the blame for the poor performance in construction has been put on the rough and tough nature of the industry itself. But research by Brown (1996) has sought to dispel what he considers are the myths and present the facts concerning the construction industry. According to him, the industry should be able to perform well in safety because of the nature of the industry and not inspite of it.

6) The efficiency of safety education and training in ensuring that all employees are well trained or well educated is being question. With enough legislation and training programme why are employers still employing untrained worker?

7) The importance of safety becomes diluted if accidents are not occurring and this will create a 'loss of fear' scenario among individuals on site. Everyone will become apathetic and complacent towards safety on site. This will create a laid back attitude towards working safely.

8) Another barrier stopping safety performance improvement in construction is that many still doubts about the value of safety and claims that 'safety does not pay'. Due to lack of confidence, clients are not committed to fund safety for the initiated project. Even the current trends of a project to engage specialist-contractors for many of the trades on project poses a barrier too. With many specialist-contractors working together, there will be a few who will fail to work safely thus endangering themselves as well as those in the vicinity.

9) Managing safety is not the sole responsibility of site managers. Safety must be managed at all levels namely: the company policy level; the project management level; the site management level; and, the individual level. Failure to manage safety at any one level will result in accidents reoccurring.

CHAPTER 4

METHODOLOGY OF DEVELOPING THE SAFETY PERFORMANCE MEASUREMENT TOOL (SPMT)

4.1 INTRODUCTION

From what has already been discussed, it is clear why safety performance is important and why, with greater emphasis on safety, the construction industry need not necessarily be the performance black spot it has been painted to be. To date, little debate has been raised as to what sort of actual safety performance is achievable given the nature and diversity of the industry; or more precisely, how improvement is to be made and how safety performance might be measured. Measuring accident frequency is reactive and is a rather outdated idea, which falsely assumes that accidents (or the lack of them) are the measures of safety performance.

In order to achieve a true safety performance level, a more proactive measurement approach is needed. The measurement tool must be able to reduce the potential for future accidents or incidents on site in addition to reporting changes, identifying contributing factors to the causes of accidents, measuring the safety culture on site and also providing remedial actions to be taken. Implementing the measuring and monitoring of safety activities is an important signal of management commitment to safety and an essential part of a positive safety culture in the construction industry.

This chapter discusses the process adopted to develop a safety performance measurement tool (SPMT) and seeks to answer the questions frequently asked about measurement, namely: what to measure, who to measure, how to measure and when to measure safety performance on site? The first section discusses how the safety control measures (SCM) were developed, identifies what the measures should be and how SPMT should be implemented. The next section explains the object-oriented development of SPMT.

4.2 DEVELOPING THE SAFETY CONTROL MEASURES OF SPMT

This section discusses the research used to develop the safety control measures (SCMs) and measurement indicators for SPMT.

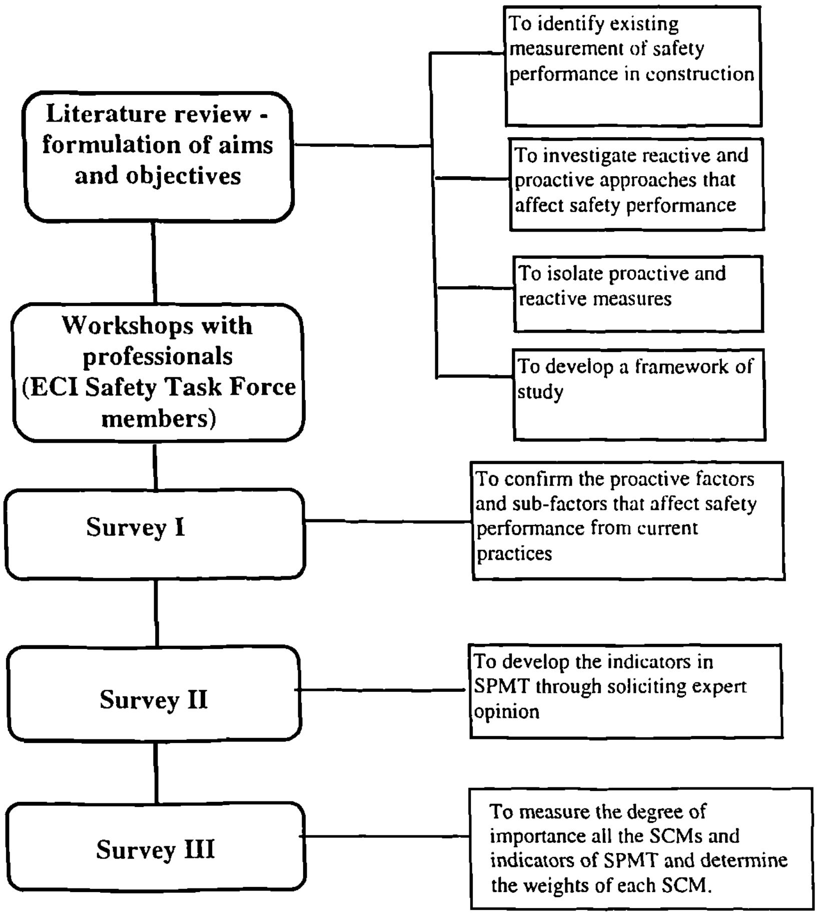


Figure 4.1 – Methodology to develop safety control measures (SCMs) and indicators for SPMT

The following steps have been chosen to develop the SCMs of SPMT:

- formulation of SCMs and indicators;
- conceptual framework of SPMT; and
- hierarchy of SPMT.

4.2.1 Formulation of SCMs and indicators

From the thorough literature review, a very clear perspective of the construction industry's safety performance was formulated. From here, SCMs and indicators were developed. The initial nine safety factors (techniques by HQ management; techniques by site management; techniques by site supervisors; engineering control; housekeeping; training; communication; safety culture and health) put forward in Survey I were derived from the literature reviews and discussion with the ECI Safety Task Force members. After carrying out Survey I, expert opinion was sought for the development of the indicators for each of the safety factors through Survey II. Finally, a further validation was carried out to reaffirm the thirty SCMs identified together with the respective indicators for the inclusion into SPMT (Survey III). A detailed explanation for each level of surveys is given in Chapter 5 and 6. Table 4.1 lists out all the thirty SCMs identified through the surveys. Once the SCMs were identified, a conceptual framework was produced. The following sections discuss the identification of the framework for SPMT.

Table 4.1 – List of thirty SCMs for inclusion in SPMT

Safety control measures

- Safety audit
- Up-to-date safety documentation
- Pre-tender risk assessment
- Procedures for reporting accidents/incidents
- Procedures for reporting near misses
- Up-to-date safety policy
- Safety meeting with supervisors
- Safety meeting with specialist-contractors
- Selection of specialist-contractors based on safety issues
- Health & Safety Committee
- Safety officer
- Induction training
- Site inspections
- Tool-box talks
- Construction risk analysis
- Method statements
- Permit-to-work system
- Machinery & equipment in safe working condition.
- Good housekeeping
- Material Safety Health Data Sheet (MSHDS)
- Emergency response system
- Suggestion system
- Communication
- Safety promotion
- Training
- Safe behaviour
- Safe working environment
- Effective health care
- Motivation to safe behaviour
- Recruiting the right person

4.2.2 Conceptual framework of SPMT

Often the argument concerning safety revolves around the fact that it is distinct from other management tasks and organisations frequently fail to manage it effectively. Lindsay (1992) argues that the same emphasis is not placed on safety as it is on other management tasks such as quality and the environment. Looking at quality, the traditional approach is for the products to be inspected and sorted for defects before they reach the customer. This has proven to be both costly and inefficient (HSE 1997). The modern approach is labelled process-based quality assurance – managing quality *in* and not inspecting defects *out* and a similar approach can be adopted for safety as suggested by Lindsay (1992). Instead of reacting to accidents/incidents, it is better to concentrate on preventing them before they occur. In other words, it is the proactive approach instead of the reactive approach.

Prevention can only stem from an effective health and safety management system and for this the construction industry needs a framework or benchmark against which to judge the adequacy of the safety situations. The approach adopted for developing SPMT is detailed in the ISO 14001 Environmental Management Standards, BS8800 Guide to Occupational Health and Safety Management System, and the voluntary eco-management auditing scheme (HSE 1997). Figure 4.2 illustrates how feedback on performance may be used in an ongoing review and development of each of the key elements. Using the conceptual framework helped to develop the indicators for each SCM. The HSE (1997) discusses each level in detail as summarised in the following section.

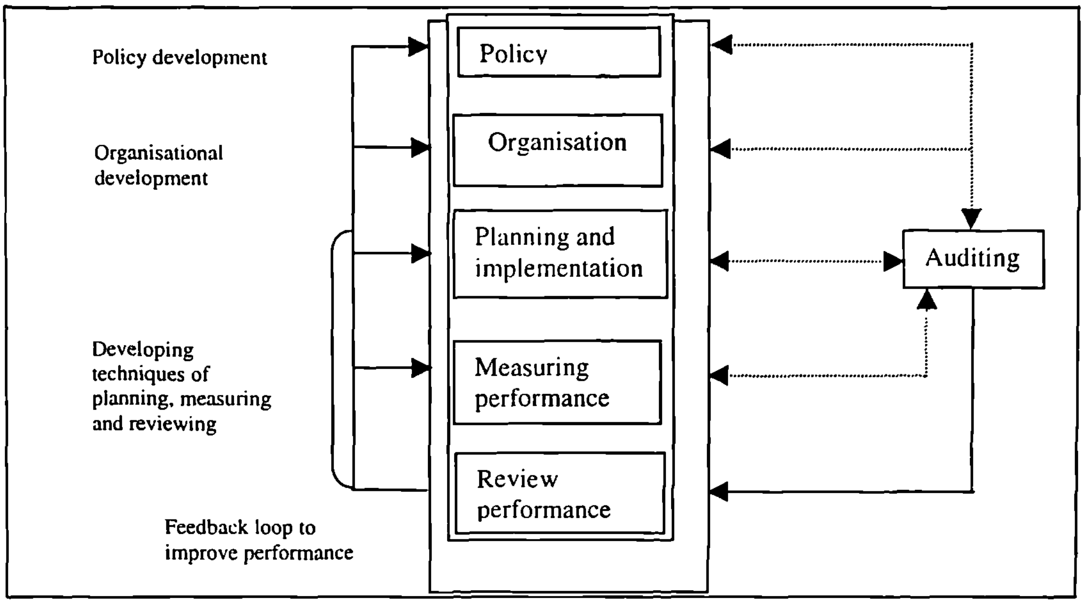


Figure 4.2 – Key elements of a safety management system (HSE 1997)

Policy and Objective

Organisations that are successful in achieving high standards of health and safety generally have health and safety policies which contribute to their business performance. At the same time, meeting their responsibilities to people and the environment in a way fulfils both the spirit and letter of the law. Their policies influence all their activities and decisions, including those to do with the selection of resources and information, the design and operation of working systems and the design and delivery of products and services.

Organising

Organising to achieve high health and safety standards is structured and operated to translate health and safety policies into effective practices. The visible and active leadership of senior managers is necessary to develop and maintain a culture supportive to health and safety management where the vision, values and beliefs of leaders become the shared knowledge of all.

Planning and implementation

Successful organisations adopt a planned and systematic approach to policy implementation with an aim to minimise the risks created by work activities, products and services. Risk assessment methods are used to decide priorities and set objectives for hazard elimination and risk reduction from which performance standards are established and performance is measured against them.

Measuring performance and reviewing

Health and safety performance in organisations that manage health and safety successfully is measured against pre-determined standards so as to reveal when and where action is needed to improve performance. In both reactive and proactive monitoring the objectives are not only to determine the immediate causes of sub-standard performance but, more importantly, to identify the underlying causes and the implications for the design and operation of the health and safety management system.

Learning from all relevant experience and applying the lessons learned are important elements in effective health and safety management. This needs to be done systematically through regular reviews of performance based on data both from the monitoring of activities and from independent audits of the whole health and safety management system.

Table 4.2 shows how SPMT is designed based on this conceptual framework.

Table 4.2 – Conceptual framework of SPMT (SCM 1-8)

Policy/Objective	Organising	Planning & Implementation	Measurement/Review
1. Safety audit	• Participation in safety audit • Receive pre-audit training • Feedback of analysis to site management	• Frequency of carrying out safety audit • Develop action plan based on safety audit	• Carry out safety audit analysis • Periodically review the audit action plan (at least once)
2. Up-to-date safety documents	• Communication of safety documents to site	• Inform and advise any changes in safety documents	• Review safety documents
3. Pre-tender risk assessment	• Communicate pre-tender health and safety plan to prospective specialist-contractors	• Carry out pre-tender risk assessment during pre-contract	• Review findings in the pre-tender health and safety plan
4. Accident/incident reporting system	• Communicate reporting system to all personnel • Only trained personnel to undertake accident/incident reporting	• Record and review all reports	• Conduct investigation on all accidents/incidents • Investigation report analysis • Review repeated accident/incident situations
5. Near miss reporting system	• Communicate near miss reporting procedure to all personnel • Provide trained personnel to review near miss reporting	• Record and review all reports	• Conduct investigations on all reported near miss • Carry out analysis on near miss situations • Review repeated near miss situations
6. Company's own safety policy	• Safety policy relates to company objectives & expectations • Communication of safety to all personnel	• Safety policy signed by responsible director	• Review of safety policy when necessary
7. Meeting with supervisors	• Communication of meetings with supervisors • Communication of actions and information highlighted during meetings	• Frequency of meeting at least once a week • Meeting to discuss work progress, health and safety matters • Record attendance	• Review any substandard work incidents • Review implementation of any previous action plan
8. Meeting with specialist-contractors	• Distribution of minutes of meetings with specialist-contractors • Communication of actions and information highlighted during meetings	• Frequency of meeting at least once a week • Meeting to discuss work progress, health and safety matters • Record attendance	• Review any substandard work incidents • Review any action plan previously implemented

Table 4.2 – Conceptual framework of SPMT (SCM 9-13)

Policy/Objective	Organising	Planning & Implementation	Measurement/Review
9. Choose only competent specialist-contractors	• Communicate company health and safety definition and expectation to prospective specialist-contractors	• Specialist-contractors to submit health and safety strategy during pre-tender stage	• Pre-qualification ability questionnaires
10. Health & Safety Committee (HSC)	• HSC includes all levels of personnel	• Develop correction and improvement procedures • Develop action plan for compliance with regulations • Develop action plan for project accountability	• Regularly review the company safety performance • Review and evaluate company procedures and implementation
11. Full time safety Officer (SO)	• SO competent and trained • SO spends at least 75% of time on project site • SO responsible for training, advice and inspection • SO responsible for overseeing all reporting of accidents/incidents and near misses	• Carry out performance evaluation on site	• Review poor performance and identify problem areas of safety activities • Take action on all sub-standard situations
12. Induction training	• Conduct induction training for all personnel on first day on work site • Develop company induction training content • Identify all those that had attended induction training	• Training not longer than one working day • Use written material and visual aids to conduct training	• Carry out formal and informal evaluation
13. Inspections	• Appoint trained and competent supervisors • Supervisors to receive risk assessment training • Communicate sub-standard work to specialist-contractors	• Daily planned inspections • Written report on all sub-standard work • Initiate actions on all substandard work either in a standard form or weekly report	• Review any substandard performance • Follow-up should define who, how and when

Table 4.2 – Conceptual framework of SPMT (SCM 14-19)

Policy/Objective	Organising	Planning & Implementation	Measurement/Review
14. Toolbox talks	• Tool-box talks carried out by trained and competent supervisors • Communicate tool-box talks on gang's particular work	• Frequency of talk at least daily for pre-tasks • Frequency of talk at least weekly for general safety • Record all talks • Initiate actions on all sub-standard situations	• Review task, method statements and work permits • Carry out performance prior work commencing
15. Construction risk analysis	• Communicate construction phase health and safety plan • Communicate risk analysis report for future orientation and training programmes	• Carry out safety briefing at work place before commencing work	• Review risk analysis with respective workers • Revise the analysis if necessary
16. Method statements	• Communicate the method statements to the respective workers • Conduct formal training when required	• Management to identify critical jobs with inherent difficulties or significant risks in its execution	• Review method statements and plan for contingencies if they prove not to be workable
17. Work permits for all work involving risks	• Design risk assessments to identify type of permit required • Permits to be issued by trained and appointed person • Permits must be properly authorised • No one can cancel, alter or override the permits except the issuer or identified personnel	• Ensure permits identify hazards and establish precautions needed • Incorporate permits to work into method statements	• Revise work permits from time to time
18. Machine and equipment in safe working condition	• Only trained or skilled personnel to handle machinery and equipment	• All machinery manuals in place for the operator or maintenance to use	• Carry out daily inspection by operators • Carry out periodic inspection by agent or manufacturer
19. Good housekeeping	• Plan storage with reference to the construction programme	• Plan open and secure storage areas • Daily clean up	• Conduct housekeeping checks

Table 4.2 – Conceptual framework of SPMT (SCM 20-27)

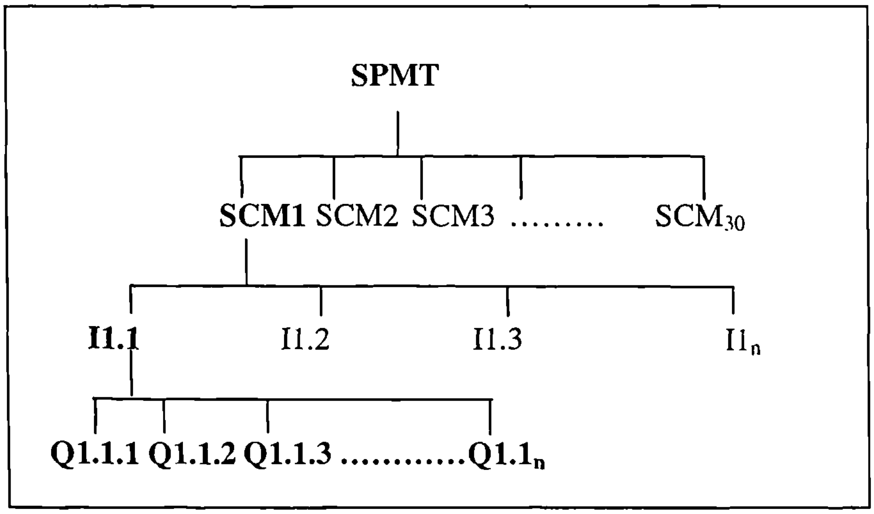
Policy/Objective	Organising	Planning & Implementation	Measurement/Review
20. Material safety and health data sheet (MSHDS) provided when required	• Management to communicate MSHDS to affected personnel • Provide appropriate training for hazardous material handling	• Check to ensure all affected personnel receive MSHDS • Ensure training is provided to all necessary personnel	• Review and up-date MSHDS if required • HQ management to keep master copy of MSHDS
21. Emergency response system exists	• Communicate emergency response system to all personnel • Provide training for emergency situations	• Carry out drills which simulate real life emergencies	• Review employees knowledge of the emergency procedures through formal and informal interactions
22. Suggestion procedures	• Communicate procedures for making safety suggestions, recommendations or improvements • Communicate all suggested safety suggestions, recommendations or improvements	• Reward personnel who have given any safety suggestions, recommendations or improvements • All commendations must be followed by written communication by management • Explain reasons for suggestion not being adopted	• Review all safety suggestions, recommendations or improvements made by personnel
23. Communication	• Clear chain of command exists throughout the project	• Good practice in both verbal and written communication	• Always check the communication process is effective
24. Safety promotion	• Communicate message of safety through printed material • Ensure signs and guarding, follows the standard codes and colours	• Message of safety on boards, posters and newsletters • Location of safety promotion must be seen by everyone at least once a day	• Review and change safety promotion when necessary
25. Safe behaviour on site	• Communicate the message that safety is important to all personnel	• Safe behaviour related to equipment, tools and machinery • Safe behaviour related to work	• Personnel to report any sub-standard situations or behaviours
26. Safe working environment	• Management to provide safe working environment to all personnel	• All requirements to meet the legal regulations	• Personnel to report of any sub-standard work environment
27. Training provided	• Only properly trained personnel to be appointed on site • Ensure all training is conducted by competent and eligible personnel	• Provide training when necessary to all relevant personnel	• Check from time-to time when refresher training is required • Formal and informal evaluation is carried out on personnel if required

Table 4.2 – Conceptual framework of SPMT (SCM 28-30)

Policy/Objective	Organising	Planning & Implementation	Measurement/Review
28. Proper health care	• Proper health care are provided to all personnel • Appropriate level of first-aid or medical care on site	• Formal procedures exist to monitor industrial hygiene	• Check the health facilities to ensure they are adequate
29. Personnel motivation	• Encourage active participation of personnel in decision making. • Ideas and problems sought from personnel	• Reward good safety performance	• Implement appraisal system
30. Recruit the right people	• Personnel have the right skills and knowledge	• Reference from previous employer • Objective data and interview	• Probationary period for new personnel

4.2.3 Hierarchy of SPMT

Based on the conceptual framework described in Section 4.2.2, the hierarchy of SPMT was developed. Figure 4.3 shows the hierarchy of the SCMs and indicators for SPMT. Each SCM (SCM1 etc) has its own sets of indicators (I1.1 etc) and each indicator in turn has its own set of questions (Q1.1.1 etc) that form the assessment process. The total score for all of the questions answered are accumulated to form the score for each indicator which then yields the score for the SCM. Details of each SCM for SPMT are given in Chapter 8 and Appendix 8.1.



Note:
SCM – safety control measure
I – indicator
Q - question

Figure 4.3 – Hierarchy of SPMT

4.3 DEVELOPING THE IMPLEMENTATION OF SPMT

4.3.1 Identifying respondents for SPMT

To ensure SPMT is comprehensive, personnel representing different facets of the construction team must be involved. The target respondents can be organised into five categories as follows:

- HQ management - Senior Management with corporate responsibility for health and safety
- Site based management - Senior Management on site
- Site supervisors - at least 2 from different disciplines
- Site operatives - at least 5 from different disciplines
- Specialist-contractors management - at least 2 managers from different disciplines

It is necessary to include all of the above categories to ensure that safety exists not just on paper but is also being practised by all on site and involvement of operatives, supervisors and specialist-contractors helps to verify the claims made by management. It was decided that more that one individual was required from the site personnel to reduce bias and to represent the various disciplines. There will be a tendency that some respondents will response just to please the management or just to make a point. The practice of involving several representatives in these categories will reduce the effect of this bias.

However, it was not appropriate to have several representatives for the office-based staff because in the main, they were communicating company policy and also because often, there would only be one individual who could answer for that category. Whilst it may have been beneficial to increase the number of site personnel involved in each category, it was decided that these numbers would provide a check against bias without over stretching the human resource involved in SPMT.

4.3.2 Methods of assessment for SPMT

SPMT uses three methods to provide the best means of measuring the existence and effectiveness of a system's safety performance:

- questionnaires/interviews to verify comprehension of the safety system;
- site observation to verify implementation and effectiveness; and
- documentation review to indicate system continuity.

Questionnaires/interviews

Questionnaires/interviews are conducted to verify a) whether personnel are knowledgeable of the safety system and b) highlight an individual's responsibility within the implemented safety policies and procedures. To be effective they must be conducted at random among the various categories identified above and personnel must be made aware that their co-operation is not to target blame but to improve the safety performance of the project. Confidentiality of the questionnaires/interviews must be maintained.

Observations

Observations are an important aspect of the safety assessment process and can verify implementation and effectiveness of safety procedures. The key to conducting effective observations lies in having a good plan and then following through in practice. The observations carried out when performing an assessment can either be scheduled or unscheduled.

Document review

The review of documents such as weekly safety meeting reports and daily observation reports provide a good indication as to whether or not a safety system is functioning effectively. It is important to note that such a review is only an indicator and should not be relied upon solely as verification. Documents themselves do not prove that a safety system is functioning well and conversely a lack of documentation does necessarily indicate the absence of a system.

The three approaches adopted by SPMT provide worthwhile indications as to the extent of all personnel's knowledge and practice towards good safety performance.

4.3.3 Frequency of applying SPMT

SPMT is intended to be applied periodically. Only through repeated assessments can safety performance be benchmarked. The question is how many times should SPMT be carried out? The frequency of SPMT depends on how committed management are to achieving a good safety performance. Only after an assessment can management identify the weak SCMs that need extra attention. These remedial efforts take time to be implemented and once that has been done, management can carry out another assessment to see how the site has improved. If the site performed well and there were no weak SCMs that need urgent attention, the management can still look at the achievements of each SCM and see how to improve the existing score. In any case, management must be prepared to study and analyse the results and take the right approach to improve the existing situation. The more assessments that are being done, the more results that can be compared and a trend can be established.

4.4 DEVELOPING A SCORING METHOD FOR SPMT

4.4.1 Designing the scoring approach for each SCM

SPMT involves input from various individuals to a set of questions together with a certain amount of work-site observations. Apart from HQ management, all respondents answer the questions on site with responses directed to respective categories of respondents. HQ management will answer the questions during their visit to site or at the main office. Questions are specifically designed for each category and it is the responsibility of the site manager to organise the completion of the questions and carry out the observations and document checks.

To facilitate timely completion, the majority of the questions require a simple 'Yes' or 'No' response or a choice from a number of options. A check box represents a true-or-false situation; if the box is checked the answer is 'Yes'; and if the box is not checked, the answer is 'No'. The option groups, where the user selects one option from a list, are best used when the value of the option is numeric. A 'Yes' or 'No' approach is employed rather than a subjective rating scale because it gives straightforward answers; either you do it or you don't. Subjective rating scales were not used so as to discourage neutral responses.

To obtain reliable answers, all the questions are answered by more than one category of respondent. The example illustrated in Table 4.3 is for the safety audit SCM . There are five categories of respondents that will respond to this SCM.

Table 4.3 – Example of SCM – safety audit

Respondents	Code	Indicator questions
HQ (HQ Management)	sa1hq	Does the HQ staff carry out safety audits?
	sa2hq	Does the HQ staff participate in safety audits?
	sa3hq	Do you receive any pre-audit training?
	sa4hq	How often do you carry out safety audits?
	sa5hq	Does the HQ staff carry out safety audit analyses?
	sa6hq	Do you send safety audit analyses to site management?
SM (Site Management)	sa1sm	Do you participate in safety audits
	sa2sm	If yes, did you receive any pre-audit training?
	sa3sm	Do you receive a safety audit analysis from HQ after every audit?
	sa4sm	Do you develop any action plan based on the safety audit analysis?
Sup (Supervisors)	sa1sup	Do you participate in safety audits?
	sa2sup	If yes, did you receive any pre-audit training?
Ops (Operatives)	sa1ops	Do you participate in safety audits?
	sa2ops	If yes, did you receive any pre-audit training?
SC (Specialist-contractor management)	sa1sc	Do you participate in safety audits?
	sa2sc	If yes, did you receive any pre-audit training?

HQ management will answer six questions related to this SCM, site management will answer four; supervisors, operatives and specialist management will answer two questions each. The distribution of questions is not based on equality, but on validity. HQ management has the most number of questions because they are responsible for the safety audit SCM. The site management also has a big responsibility in carrying out safety audits. As for the rest of the categories (supervisors, operatives and specialist-contractor management) questions forwarded to them were asked to validate the claims made by both HQ management and site management. Therefore it is not necessary for each SCM question to be answered by all categories. Sometimes verifications through observations and document checks also play an important role. Table 4.4 shows the percentage distribution of questions among the categories of respondents that will respond to each SCM. The design of SPMT must be as manageable as possible. It is important to minimise the number of questions without significantly affecting the output. That was one of the reasons that the questions were designed only to be answered by particular respondents. The total of percentage from Table 4.4 shows that site management plays an important role followed by HQ management and site supervisors. Operatives contribute the least among all five categories. The document checks and observations both have almost an equal contribution.

Future work in developing SPMT may consider reviewing these ratio.

Table 4.4 – Categories of respondents responding to each SCM

Safety control measures (SCM)	max score for each SCM	Percentage distribution of questions among categories of respondents						
		Hq (%)	Sm (%)	Sup (%)	Ops (%)	Sc (%)	Obs (%)	Dc (%)
Safety audit	166	40	24	12	12	12		
Up-to-date safety documentation	70	43	43					14
Pre-tender risk assessment	80	63	25					12
Procedures for reporting accidents/incidents	329	26	35	12	12	12		3
Procedures for reporting near misses	284	12	42	14	14	14		4
Up-to-date safety policy	150	40	13	13	13	13		8
Safety meeting with supervisors	170		53	35				12
Safety meeting with specialist-contractors	170		53			41		6
Selection of SC based on safety issues	60	67				33		
Health & Safety Committee	130		100					
Safety officer	140	36	64					
Induction training	930		25	25	25	25		
Site inspection	240		13	67		17		3
Tool-box talks	90			89				11
Construction risk analysis	80		25	50		25		
Method statements	70		86					14
Permit-to-work system	80		88					12
Machinery & equipment in safe working condition.	20		100					
Good housekeeping	130		77			23		
Material Safety Health Data Sheet	70	14	44	14	14	14		
Emergency response system	100		40		30	30		
Suggestion system	240		33	21	21	21	4	
Communication	120	8	41	17	17	17		
Safety promotion	100		50				50	
Training	320	3	28	22	22	22		3
Safe behaviour	480				42	42	16	
Safe working environment	240				33	33	33	
Effective health care	100	10	30	20	20	20		
Motivation to safe behaviour	160		25	25	25	25		
Recruiting the right person	40	75	25					
Total		**437**	**893**	**436**	**200**	**339**	**103**	**103**

Notes:
Hq management
Sm – Site management
Sup- Site supervisor
Ops – Operatives
Sc- Specialist-contractors
Obs– Observation
Dc – Document checks

4.4.2 Determining the scoring points for SPMT

Having developed the questions and obtained responses, the information gathered must be assimilated appropriately to find out how safe the sites are. For this, a scoring system was developed based upon the response to the questions forwarded to each respondent. For Yes/No questions, 10 points were given for a 'Yes' and a zero score given for blank answers (No). In SPMT the values 0-10 were chosen because it allows the data to be managed more easily. The option category has its own pre-determined points system too. Even here, any numerical value can be assigned to each option answer. There is no hard and fast rule to it. All the common SCMs are calculated from different respondents in two stages: Stage 1 gathers all the answers to the respective SCMs from different categories of respondents; Stage 2 gathers the total from stage 1 to give a grand total for the particular SCM. An example is given below for a safety audit based on the questions in Table 4.3.

Stage 1

- **Respondent - Head office management**

Subtotal A =sa1hq + sa2hq+ sa3hq+ sa4hq+ sa5hq+ sa6hq

= sahq

- **Respondent - Site management**

Subtotal B =sa1sm+sa2sm+sa3sm+sa4sm

= sasm

- **Respondent - Supervisors**

Subtotal C =sa1sup+sa2sup

=sasup

- **Respondent - Operatives**

Subtotal D =sa1ops+sa2ops

=saops

- **Respondent - Specialist-contractors managers**

Subtotal E =sa1sc+sa2sc

=sasc

Stage 2

Total safety audit

=subtotal A+ subtotal B+ subtotal C+ subtotal D+ subtotal E

=sahq+sasm+sasup+saops+sasc

=**sa** (total score points for Safety audit SCM from all categories of respondents)

The same process is repeated for all of the other 29 SCMs.

4.4.3 Designing the scoring matrix for SPMT

The method adopted to measure safety performance must be able to do the following:

- measure the safety performance category of each SCM; and
- measure the safety performance category of the whole project.

✓

The approach chosen is called the Objective Matrix or OMAX recommended by Riggs (1985). OMAX is a method of measuring performance using the results obtained to make improvements. The matrix attempts to convert measurement of current performance into improvements of future performance. OMAX is widely used in the performance measure of productivity but the matrix can be adapted to fit most production or construction situations. OMAX has won respect for its general utility as well as its simplicity and ease of application.

The matrix consists of five main components (Table 4.5) as follows:

- the performance criteria of SCMs (what is to be measured);
- the performance scale (which compares the measured value of the criterion to a standard or selected benchmark value);
- the weights (which determine the relative importance of each SCM to each other and to the overall measure of safety performance);
- the value (which is the result of multiplying the score with the average); and
- finally the performance index that is SPMT Index to indicate and track performance (which totals the sum of each SCM value).

Table 4.5 – Sample of OMAX developed for SPMT

SCM$_1$	SCM$_2$	SCM$_3$	SCM$_4$	SCM$_5$	SCM$_6$	SCM$_7$	......SCM$_{30}$	
								Points accumulated
								10 9 8 7 6 5 4 3
								2 1 0
S_1	S_2	S_3	S_4	S_5	S_6	S_7	S_{30}	Score (1)
W_1	W_2	W_3	W_4	W_5	W_6	W_7	W_{30}	Weight (2)
$S_1 \times W_1$	$S_2 \times W_2$	$S_3 \times W_3$	$S_4 \times W_4$	$S_5 \times W_5$	$S_6 \times W_6$	$S_7 \times W_7$	$S_{30} \times W_{30}$	Value (1x2)

SPMT INDEX

$$= \frac{\sum_{i=1}^{10} S_i \times W}{10 \times \left(\sum_{i=1}^{10} W_i \right)} \times 100\%$$

Performance scoring

Performance scales for each SCM are contained in the matrix and range from 0 to 10 as in the OMAX developed for productivity performance. Predetermined benchmark values are entered into the boxes representing appropriate scores for each SCM. The scale is anchored by a designated value at two levels:

- level 0 – no achievement; and
- level 10 – a realistic estimate of results that can be attained.

The benchmark value of 0 is where no safe performance exists on site. On the other hand, the benchmark value of 10 represents the ultimate expected achievements. Once these benchmarks are established the steps between them are usually assigned in equal increments. For example, if the maximum score for a SCM – safety audit is 166 and the minimum score is 0, then the division will be divided by a ten scale division: 166/10 = 16.6. That is, level 0 = 0, level 1 = 17, level 2 = 33, level 3 = 50, level 4 = 66, level 5 = 83, level 6 = 100, level 7 = 116, level 8 = 133, level 9 = 149 and level 10 = 166. The same process is repeated for the other 29 SCMs each with their own maximum score but common minimum score of 0. The division will still be divided by 10.

Importance weightings

The weightings given for each SCM vary according to its level of importance. The importance level for each SCM was determined through the Survey III using fuzzy logic and will be explained in detail in Chapters 6 and 7. Assigned weights - 100 points distributed among the SCMs - have reflected their importance as agreed by the respondents. Weight assignment is not trivial for it provides an opportunity to direct attention to the SCMs that have the strongest influence on safety performance.

Calculating the score

The performance value attained is entered at the top of each column. The points achieved are translated to a score by circling the appropriate numbers on the scale. For instance, the points accumulated for the safety audit SCM assessment is 105. This means it does not meet score level 7 but does exceed score level 6 (between 100 and 115). The level is the transferred into the column as shown in Table 4.6.

Table 4.6 – Example of calculation of safety audits SCM performance score

Points	Score		
105		**Points accumulated after an assessment**	
166	10	score 10 = 166	
149	9	149≤ score 9 ≤ 165	
133	8	133≤ score 8 ≤ 148	
116	7	116≤ score 7 ≤ 132	
100	**6**	**100≤ score 6 ≤ 115**	**The score is 6**
83	5	83≤ score 5 ≤ 99	
66	4	66≤ score 4 ≤82	
50	3	50≤ score 3 ≤ 65	
33	2	33≤ score 2 ≤ 49	
17	1	17≤ score 1 ≤ 32	
0	0	0≤ score 0 ≤16	
6	**Score**		
62	**Weight**		
372	**SCM index**	**(score x weight)**	

The level will yield the performance score of each SCM. The following are the groupings for the scoring for SCMs:

Table 4.7 – Interpretation for the SCM performance score

Scale	Indication of scores
10	Excellent
8-9	Very good
6-7	Good, but still need to improve the SCM
4-5	Moderate/poor, need to work harder to improve the SCM
0-3	Unacceptable – need to take urgent actions

From the grouping above, the management will be able to focus on the weak SCMs to improve safety performance. Any SCMs that achieve a score of 10 are excellent, meaning that the SCM was carried out as required and understood by all affected personnel. Scores between 8-9 are still considered very good and the next step is to ensure 100% compliance with the safety factors. The scores between 6 and 7 are still considered good, but management needs to improve the affected SCMs. The scores 4-5 are considered moderate/poor which means the management needs to pay extra attention to these weak SCMs. Lastly for the score between 0 and 3 means that the respective SCMs either do not exist on the project or are really not well implemented. This scoring is unacceptable and any SCM within this range must be attended immediately. Urgent remedial action must be taken to improve the situation.

SPMT index

The various SCMs, their weights and the scores can be combined into a single performance index, which can be used for tracking and evaluation. This final phase of matrix measurement ties together SCM scores and weights to determine the safety performance index for the project as follows:

$$\frac{\text{Total SCM index accumulated for all 30 SCMs}}{\text{Total SCM maximum}}$$

$$= \frac{\sum_{i=1}^{30} S_i \times W_i}{10 \times \left(\sum_{i=1}^{30} W_i \right)} \times 100\%$$

Where S is the score for SCMs accumulated through an assessment; and W is the weight for the SCMs. The score is based on the percentage achieved.

The performance index is a composite indicator of total performance during a measurement period. It can be charted over a period of time and uses as a record of progress. The OMAX is essentially a report card and will reveal the following information:

- the total points achieved for each SCM;
- the maximum points achievable for each SCM;
- the score (1-10) for each SCM;
- the index (score x weight) for each SCM;
- the weight for each SCM;
- the total score – that is the SPMT index achieved; and
- the interpretation of SPMT index.

The results of each assessment will enable comparison of the indices between the contractors, specialist-contractors (internally) and between sites (externally). The SPMT index will be used to compare the results. The achievement of SPMT index can be interpreted as follows:

Table 4.8 – SPMT Index result interpretation

Scale (%)	Indication of safety culture
90-100	Excellent
70-89	Very good
50-69	Good
30-49	Moderate/poor - need to improve the safety culture
0-29	Unacceptable – need to take urgent action

Any achievement above 90% has excellent safety performance where the management gives safety as high a priority as other main business drivers. Projects that obtain between 70 –90% are also high achievers and have very good safety performance but there is still room for some improvement. The groups that achieve between 50-70% are considered good and still regard safety as a priority but could improve. Projects obtaining between 30-50% are considered to have a moderate or poor safety performance and need to look at ways to improve the safety culture on sites. Lastly projects achieving below 30% are unacceptable. Management has not put safety as a number one priority, the implementation of safety on site is not effective and urgent steps need to be taken.

4.5 DEVELOPING AN INTERACTIVE SPMT

It was decided that SPMT should be an interactive and object based application. SPMT was designed as a computer-aided object-based interactive assessment tool to measure safety performance on site. An interactive tool would be able to feedback the correct information much faster and thus save time.

4.5.1 Choosing the Software

The software selected had to be object-based, which could be used as a development for client/server application. For this situation, Microsoft (MS) Access was chosen, as it is a powerful database package and a development tool under Microsoft Windows which ensures wide applicability. Using the capability of MS Access to attach to files stored on a SQL-server (standard query language), MS Access can be used as a development platform to produce applications for enterprise-wide database tasks. MS Access operates as a stand-alone product with the ability to store data in its own native format as well as to attach to PC-based databases in a variety of formats (including dBASE, FoxPro and Paradox). These features enable immediate access of results through developing database applications which store data in a PC-based data format.

An additional advantage is that Microsoft Windows is a popular operating system, used in virtually all PCs. Jones (1997) agrees that MS Access lets developers create applications that are completely windows-compliant, with the look and feel of the Windows graphical environment without the need to become familiar with a complex development language such as C++. With MS Access there is no requirement for a main program consisting of hundreds of lines of codes to control the user interface. A large part of the development task consisted of designing objects (such as forms and queries) and visually tying these objects together with macros. The Windows environment means that the software responds to events performed by the user by means of clicking an icon or selecting menu options. Jones also comments that as a Windows package, MS Access also supports dynamic data exchange (DDE) and object linking and embedding (OLE). This feature allows easy exchange of data between different Windows applications.

The following are the steps taken to develop SPMT using MS Access:

- designing tables;
- designing forms;
- designing queries to support application;
- implementing macro;
- adding macro to forms;
- putting the application together;
- providing navigation throughout the application; and
- sharing data with OLE.

Designing tables

A database table is the basis of the MS Access application. As a result, creating, maintaining and manipulating tabulated data (and the process of database design that precedes table creation) must take place early on in the process of application development (Jones 1997). It is also important to determine the type of data required, the size and a name for the data. For SPMT, the number of responses to each question for each SCM by the level of respondents is required. In order to achieve this, data definition must be identified and, for each respondent, it was necessary to list out all of the questions relating to each SCM. Not all the respondents contribute to the thirty SCMs - only the ones that are related to each category of respondents will be asked as shown in Table 4.4.

After listing the questions, it was necessary to gather all related questions for each level of respondents thus creating five main tables for each category of respondents (Figure 4.4). Additional tables for document checks and observations were created and together these two tables form part of the exercise in carrying out SPMT. The site management team will answer both questions.

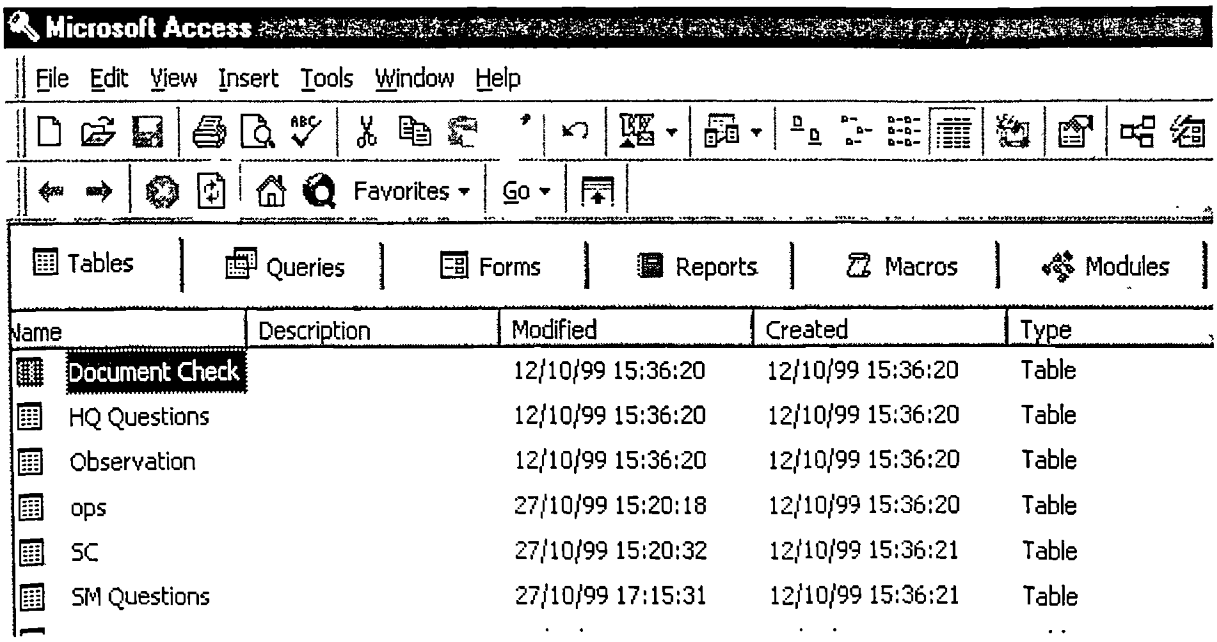


Figure 4.4 – Tables for each category of respondents in SPMT

Once the field name had been defined, it was also important to determine the data type. This means defining both the field type and the size for the field in the same cases. There are two types of data for the tables in SPMT - the 'Yes/No' fields and the number fields. A 'Yes/No' field contains a 'Yes/No', 'True/False' 'On/Off' or other Boolean entry (such as –1 for Yes or 0 for No). In this case as mentioned earlier, it was decided that for every 'Yes', a score of 10 will be given and 0 for every 'No'. The majority of the questions will have Yes/No fields.

The next type of field used is the number field. This field stores numeric data where calculations can be performed and allow the user to store integers or fractional values (using decimals) as well as negative values. For SPMT, this field was chosen to be used for the option groups. The field size was set to byte, allowing whole numbers to up to 255 entries. A validation was used to create an option group of six choice, type <=6 in the Validation Rule Box. Then, in the validation text type 'Please enter a category number between 1 and 6'. This rule is an expression used to define data-entry rules while validation text is for text that appears if invalid data is entered.

Designing forms

The next step is to develop the actual forms in MS Access - providing both a means for adding and editing data and a foundation for the user interface for any application. Forms can be created by means of a Form Wizard or manually using the Form Design Window. In this SPMT, the forms are designed using Form Design (Figure 4.5)

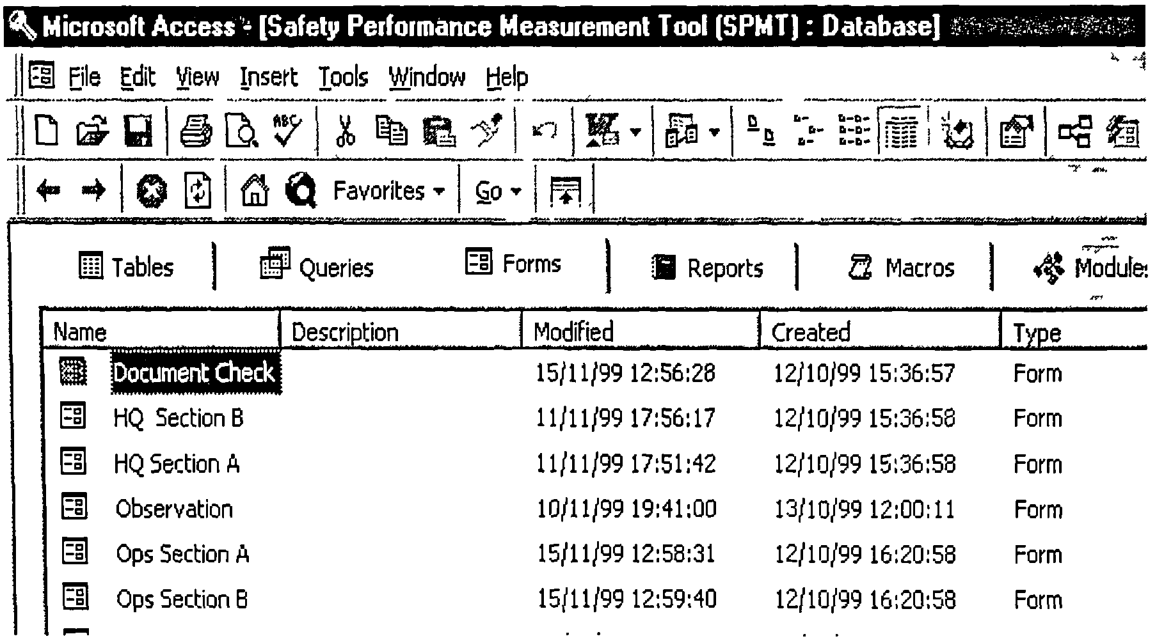


Figure 4.5 – Example of forms created for SPMT

The tables in Figure 4.4 provide the basis for designing the forms. Here the questionnaires for each respondent category will be a form on its own and since the questionnaires are long, there may be more than one form for each category of respondent. Figure 4.5 shows part of one of the forms created for SPMT. All together there are 23 forms for all category of respondents. Questionnaires with a data type of 'Yes/No' will be answered using a check box. Check boxes are used to represent a true-false situations; if the box is checked the situation is TRUE; and if the box is not checked, the situation is FALSE. Figure 4.6 shows an example of the two types of questions for HQ management. For the option group, only one choice is permissible and every choice gives a different score.

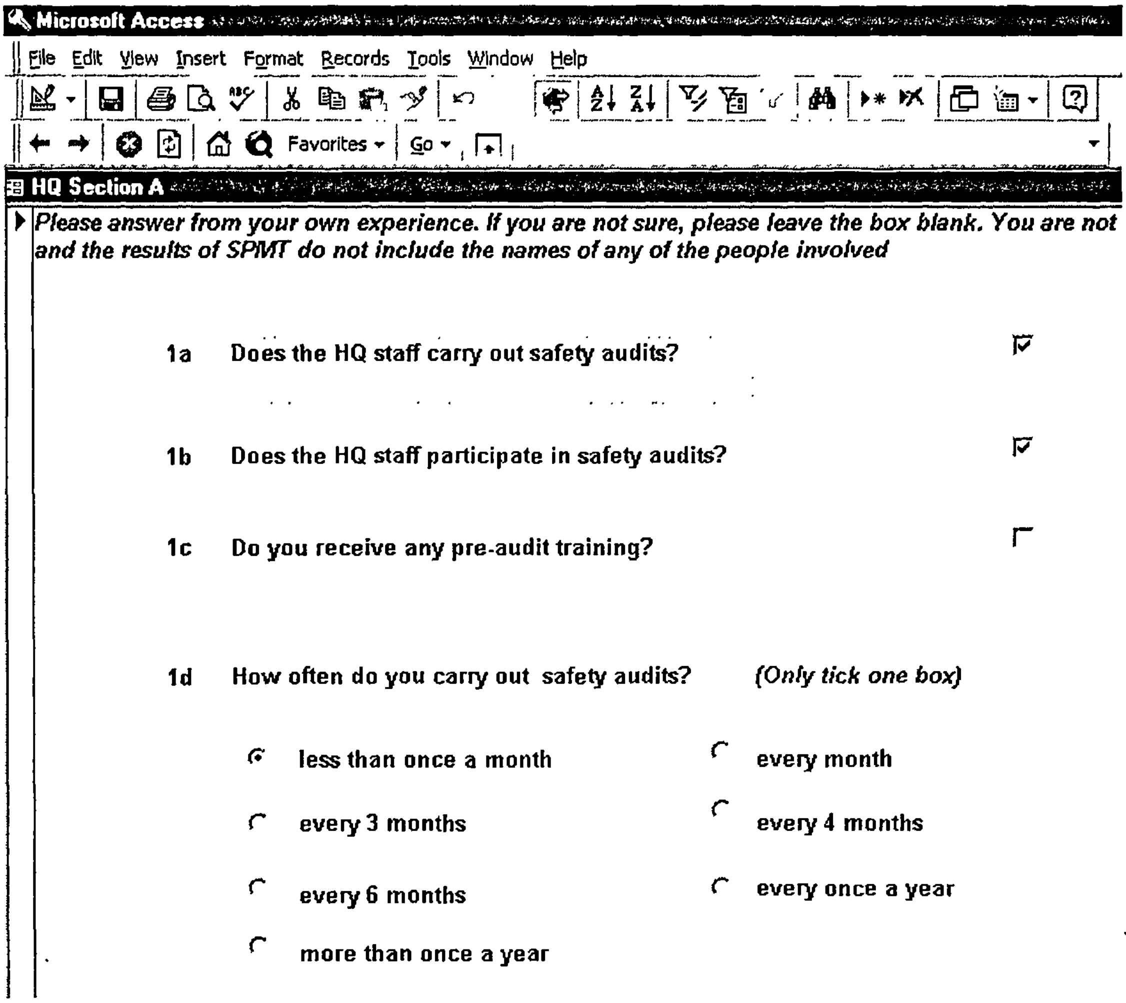


Figure 4.6 – Example of questions format designed for SPMT

Designing queries to support application

Queries allow the user to retrieve the specific data method used to perform any given task and can also be used to sort data, to ask questions about the data stored and to calculate totals of numeric fields. Forms can be based on the results of queries.

In developing SPMT, queries play an important role. All the answers representing 'Yes' and the choice from option groups will be calculated to give the total for all SCMs. First, MS Access presents the data as a set of records in what is called a dynaset. A dynaset strongly resembles a table; it is a dynamic set of records derived from a table that the query is based on. If changes are made to the data in the answer provided by the query, the data in the original table will not change.

Queries can be created manually or using the Query Wizard. The basic process is as follows: open new query, add the fields from the desired table or tables to the query, and ask any questions that you need to ask about the data. Before designing the query, it is important to plan the framework. The objective of creating a query is to know the total numerical value scored for each SCM by all respondents. To perform the calculation in the query, open the query in 'Design View' and choose 'View' – 'Total'. Inside the 'Total' row in the query grid appears the designation 'Group By' on every field. To choose the options, click the down arrow to open the list box of possible calculation types and choose the desired type. An example of how the queries are used to calculate the score will be shown using the safety audit SCM. Table 4.3 shows the questions related to safety audit SCM and Figure 4.7 show the schematic for the calculations. Figures 4.8 and 4.9 illustrate an example of how queries were used to calculate the responses for safety audit SCM.

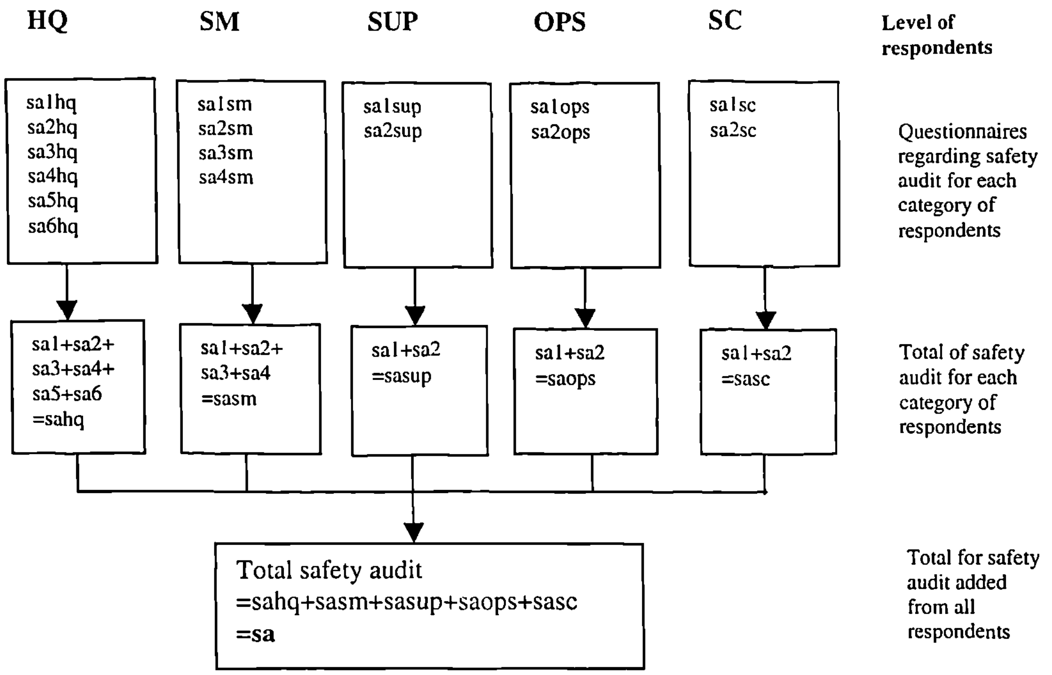


Figure 4.7 – Schematic showing an example of calculation for the safety audit SCM

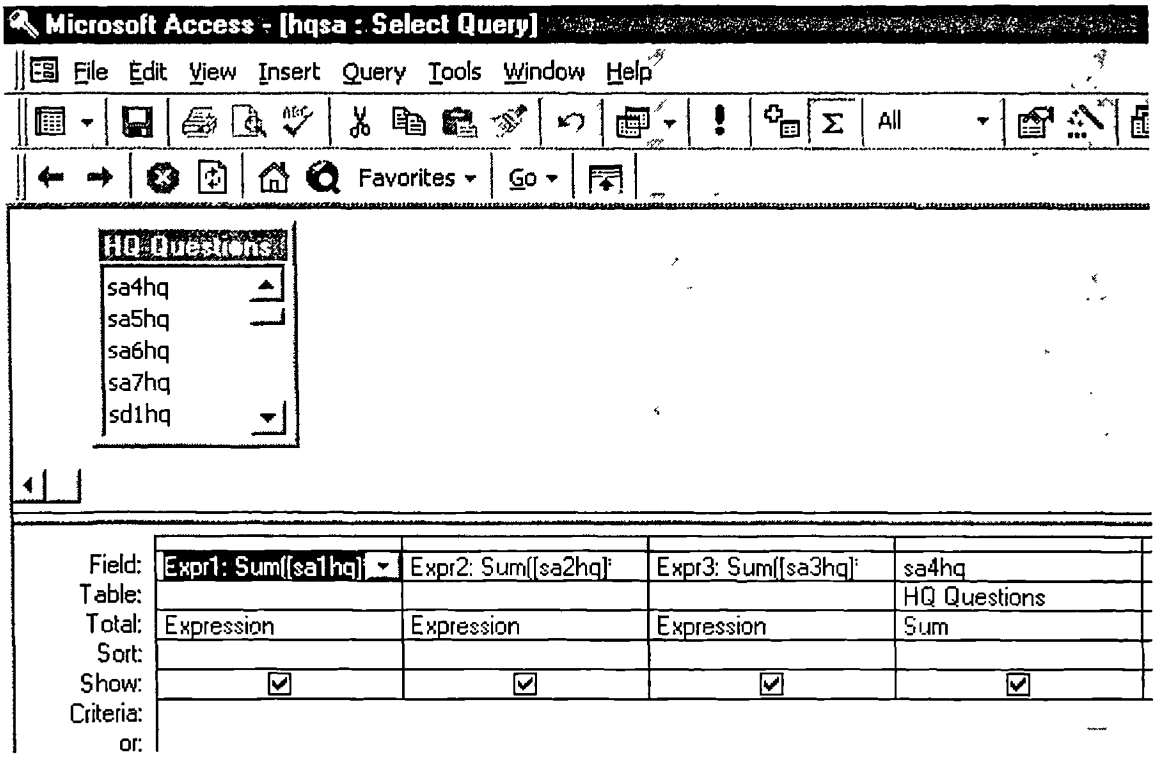


Figure 4.8 – Examples of queries for HQ management responses for the safety audit SCM

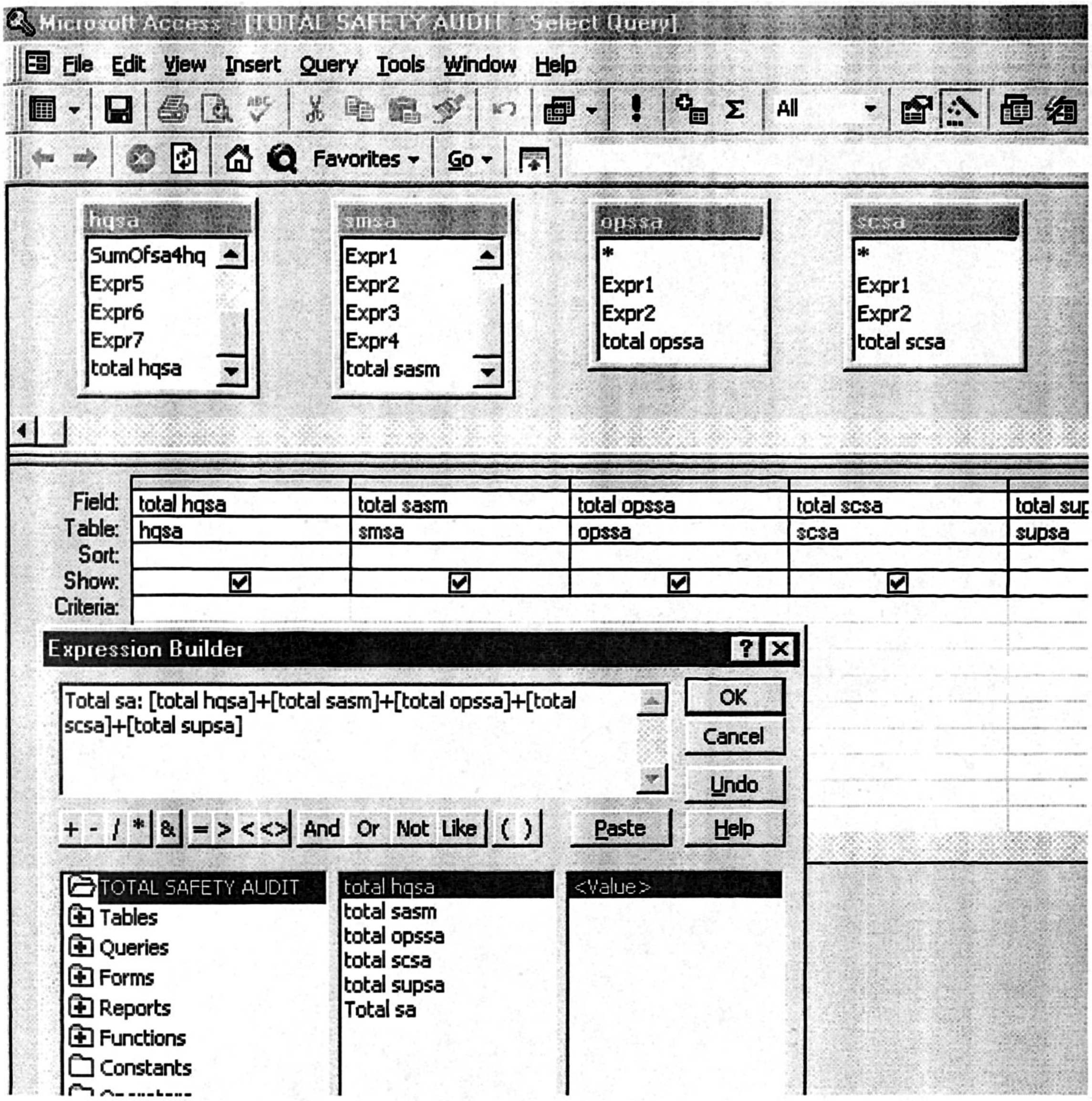


Figure 4.9 – Example of total calculation for the safety audit SCM from different categories of respondents

Implementing macros

Macros are a fundamental part of creating an application in MS Access. They can provide complete menu-driven systems that will help users. A macro is essentially a list of actions that is specified in advance and, when it is run, MS Access carries out that list of actions. This can be done by choosing the actions to be performed in a macro window. The macro window is divided into three areas - an upper portion that contains the macro name, the actions and the comments. The macro name column specifies the actual name given to a macro. Within the action column, the actions are selected from a list of actions in a pull down menu and the comment column describes what the macro does. The comments are optional and provide a reference to help remember how the macro operates.

Adding macros to forms

Once the macros have been defined, the next step is to attach them to forms that have been developed. In SPMT, most forms have a dialog-box - 'Next' or 'Previous', - providing the option of either opening the next form for the former or returning to previous forms for the latter. This allows flexibility for the user to either continue with the questionnaires on the following page or return to view the previous page. Most of the macros developed in SPMT are mainly for open or close form actions.

Putting the application together

Once the collection of objects needed to form a complete application is ready, it is then necessary to bind them all together. To do so, macros need to be created and the code for event procedures that will be used to open or run the various objects in the applications defined. To ease the user, it is wise to start with the main page that introduces SPMT as in Figure 4.10. This can be done using simple blank forms to create a few pages of introduction to the tool mainly the aim, the respondents involved, the method of carrying out the assessments and viewing the score.

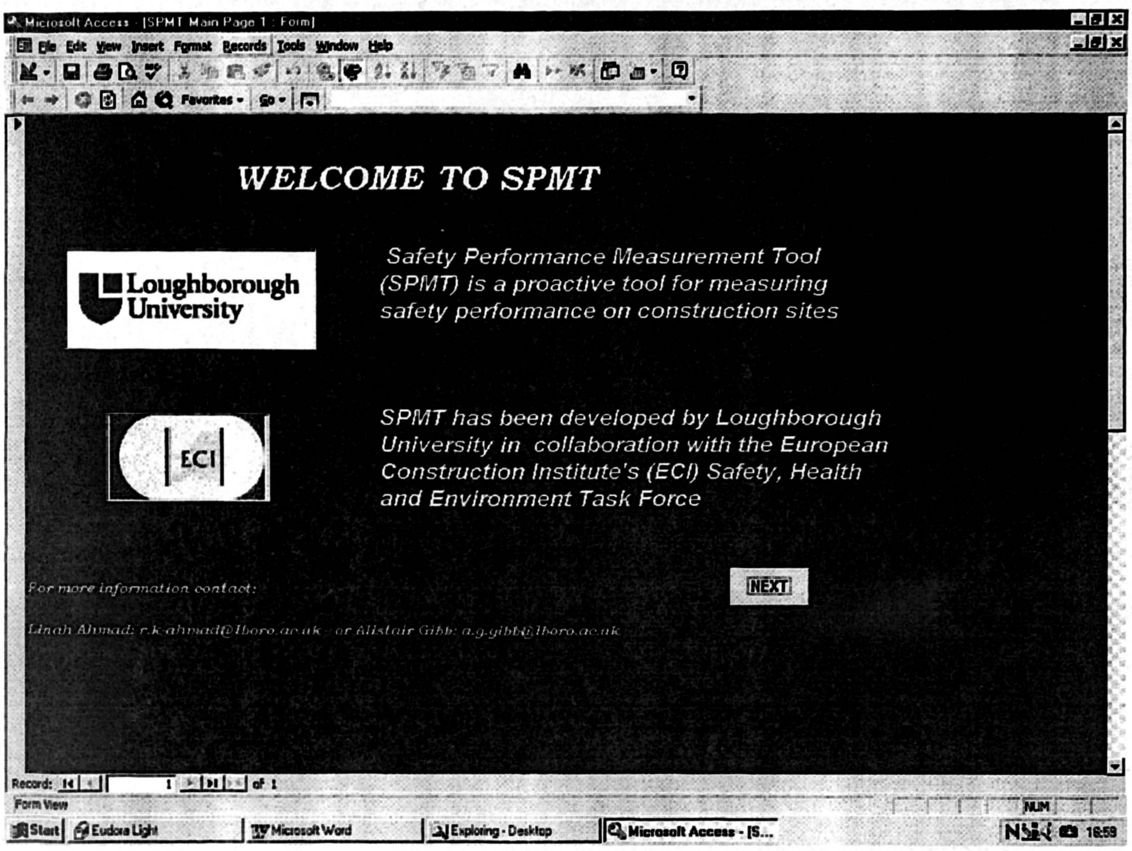


Figure 4.10 – Main page of SPMT

Providing navigation throughout the application

One of the most important design tasks is to plan and implement precisely how users will navigate through the various tasks of the application. There are two types of navigation that are explained as follows:

Navigation within the forms

For navigation while inside a form, one can control the natural flow by changing the Auto Tab and Tab Index properties for a given field in the form. The Auto Tab property determines whether a tab is generated when the last allowable character is entered into a field. When set to 'Yes', filling a field generates a tab, forcing the form to move to the next field.

Navigation between the forms

Navigation between the forms is usually done with menu options or with command buttons that will call up desired forms when needed. Of the two options (menu versus command buttons), command buttons tend to be more readily noticed by the user and all these were used in SPMT.

Sharing data with OLE

OLE (object linking and embedding) is a Windows protocol that enables data in a form of objects stored in one Windows application to be used (by means of linking and embedding) within documents in another Windows application to provide OLE support. OLE can be created in any Windows application that supports OLE (most Windows applications provide OLE support).

Windows applications that support OLE can be an OLE client, OLE server or both. OLE clients can accept data from other windows packages and OLE servers can provide OLE data to other packages. MS Access can act as both an OLE client and an OLE server. The source document is the document that is providing the OLE data while the destination document receives the OLE data.

Jones (1997) explains OLE documents can consist of either portions of documents (such as paragraphs of a Word document or a range of cells in Excel or entire files. With linking, the OLE object remains stored in a separate file and a link is established between the OLE object in MS Access and the original file. For example, if part of an Excel spreadsheet is stored in an OLE object filed as an MS Access table by means of linking, the MS Access file will contain a reference to the original Excel spreadsheet file (Jones 1997). Linking is the preferred method to use when the OLE objects in MS Access are to reflect any changes to the original data under the control of the source application. All linking in SPMT is between MS Access and Excel spreadsheets - between the total score of all the thirty SCMs and the score matrix.

Embedding on the other hand refers to data from the Windows application which is literally inserted into a MS Access object; hence it becomes part of the MS Access database. The data might still exist in the original file, but within MS Access it has become a copy of the data in the source application (Jones 1997). While changes can be made to the embedded data, the original data will remain unchanged with the advantage that it is easier to maintain portability of the data, without worrying about breaking the linking between drive locations of linked objects.

4.5.2 System architecture of SPMT

After defining all of the necessary planning and designing of SPMT, the whole system can be put in place. Figure 4.11 show the schematic for the system architecture of SPMT, providing an idea of how the whole system works. The design should allow all the levels of respondents to use the system and before designing this tool, it was important to consider the skill level of the end users. It would be useless to design a complex and powerful industrial-strength application if it was so far over the heads of the users that no one understood it. For this reason, the design of SPMT is simple and easily understood by any reasonably computer-literate managers who will need to use it to obtain the results of the assessment. It is also simple enough for any user to answer the questionnaires by simply following the command buttons provided.

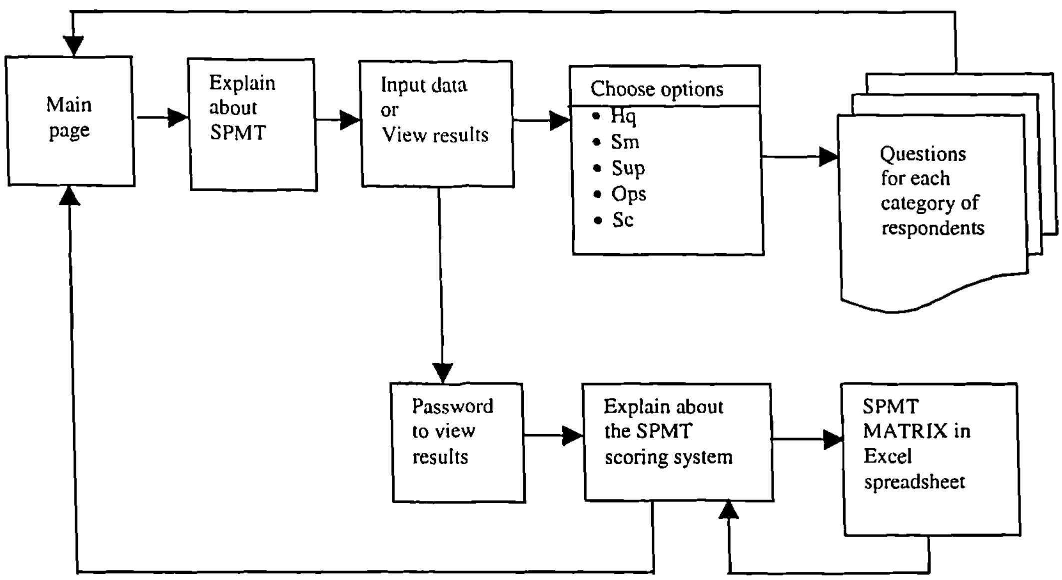


Figure 4.11 – System architecture of SPMT

Having come to the main screen, each of the respondents goes through the navigation buttons provided. The next page briefly explains the aim and objectives of SPMT and is followed by a page asking what their task is - either to input data or to view the results. From here all respondents have to choose which category of respondents they are and they then answer the corresponding questions. Respondents do not know the scoring systems adopted and they simply responded to the questions at face value. Once they have completed their answers, they go back to the main menu. Only the management personnel are allowed to view the score data which is password protected. Appendix 4.1 provides a CD ROM version of SPMT.

4.7 SUMMARY

1) The literature review has helped to identify the safety scenario as it stands in the construction industry. Many in-house measurements are practised in the petrochemical industries with safety a top priority. Overall, the majority of the different measurement techniques recognised the benefits of adopting the proactive measures as opposed to reactive ones.

2) This study has adopted the HSE ISO 14001 Environmental Management Standards BS8800 Guide to Occupational Health and Safety Management System as the framework to develop SPMT. This framework involves the following steps: policy/objective; organising; planning/implementing and measurement/reviewing.

3) This chapter has identified the following categories of respondents that would be involved with SPMT. It was decided that all levels of personnel on site would be included. The agreed levels are:
   - HQ based management;
   - site based management;
   - site supervisors; and
   - site operatives; and
   - specialist-contractors management.

4) In order to ensure that a several disciplines are covered on site, it was decided that more than one personnel will answer the questions for each site-based category of respondent. This approach will also limit any bias from the responses. The more respondents answering the questions from the supervisors, operatives and specialist-contractor management the more reliable the results will be.

5) SPMT comprises three parts - questionnaires/interviews; observations and document checks. It was decided that all three approaches must be applied to measure the existence and effectiveness of safety performance on site.

6) In order to quantify the measurement of safety performance using SPMT, a scoring method was designed. Two types of questions are used - the 'Yes' or 'No' approach where every 'Yes' scores 10 points, each 'No' scores zero and each option group has various predetermined scores.

7) The points score from the questionnaires, observation checks and document checks are accumulated under the respective SCMs. From here, the results and scores for each SCM, the index for each SCM and the total index of SPMT are given.

8) The results reveal the following:
   - The overall SPMT index;
   - The score for each SCM;
   - The percentage of points scored for each SCM and subsequent improvements to be made.

9) These scores enable weak SCMs to be identified and their performance improved. The information also helps to determine at which category of respondents the safety management system has failed. The management must remember that the aim of the exercise is not to put blame on anyone but instead to learn from it and improve safety performance.

10) In order to implement SPMT, it was decided that it must be interactive to encourage the user to use it. For this purpose, MS Access was chosen to design SPMT. MS Access also calculates all of the scores from the different respondents, accumulates them under the respective SCMs and calculates the total points achieved. From here, the data is linked using OLE with MS Excel to display the matrix OMAX.

CHAPTER 5

METHODS FOR GATHERING DATA FOR DEVELOPING SAFETY CONTROL MEASURES

5.1 OVERALL PHILOSOPHY /APPROACH

In order to fulfil the objectives of the research and in accordance with the methodology defined in Chapter One, the approach shown in Figure 5.1 was chosen.

Survey I
- Pilot test
- Main survey to ECI Task Force members to distribute to PC and SC
  Aim: To identify the factors and sub factors that affect safety performance on sites

↓

Survey II
- Expert opinion using the ECI Safety Task Force members
  Aim: To identify the indicators that affect safety performance on sites

↓

Survey III
- Pilot test
- Main survey to top UK and top mainland European contractors
  Aim: To validate the safety control measures and indicators that affect safety performance on site

↓

SPMT SAFETY CONTROL MEASURES AND INDICATORS

Figure 5.1 – Flow chart of the data collection process

The aim of carrying out three levels of surveys was to establish the following issues:

- to identify the critical and important proactive factors and sub-factors that affect safety performance on construction sites (refer to Figure 4.3 for the hierarchy of SPMT);
- to identify the proactive indicators that contribute to ensuring safety on construction sites; (refer to Figure 4.3 for the hierarchy of SPMT); and
- to validate the importance of all the identified safety control measures and indicators of SPMT.

The extensive scope of research has lead to the need for the information gathered to be validated. In order to do so, opinions from the construction industry provided the validity besides giving added important information. The methods in Figure 5.1 were chosen to gather the relevant information. The following discussion will focus on each level of surveys, the questionnaire construction and the target sample.

5.2 SURVEY I

5.2.1 Pilot test

Oppenheim (1992, pp 47) stressed the importance of pilot testing as follows:

"Questions do not emerge fully-fledged; they have to be created or adopted, fashioned and developed to maturity after many abortive test flights. In fact, every aspect of a survey has to be tried."

- the pilot testing is carried out by administering the questions to a smaller sample than that to be used in the actual study;
- it is used to assess the reliability and validity of variables before carrying out the actual study; and
- the pilot test is used as an opportunity to gather any missing information and clear up any ambiguity from the questionnaire.

The Survey I pilot test was distributed to eight members of the ECI Safety Task Force who attended the meeting on 8^{th} September 1998. The response was good and comments were incorporated in the actual questionnaires. The pilot test helped to refine the wording, ordering, structure and layout of the questionnaire. It also helped to prune the questionnaire to a manageable length.

One good suggestion from the pilot test was rating of the responses. Responses from the pilot test were skewed towards the not important and very important region. Suggestion was made to clearly define the rating scale for each level such as using the Likert's five-point or seven-point scale. As an example, in the pilot test, the instruction was to rate the sub-factors with the score 1 representing no importance to 5 being very important. In the actual survey, the rating was defined further as explained in section 6.2.3.

5.2.2 Main survey

The main survey was carried out to identify all the safety factors that influence safety performance on site. It was important to send the questionnaires to a wider sample to have a more representative feedback from the construction industry. At this stage, the structure of the questionnaire was improved compared to the one used on the pilot test. The main survey questionnaire was extensively reviewed with Mr Trevor Thompson from Kvaerner Process Ltd (UK).

After a few follow-ups of phone calls and emails, a total of 63 questionnaires were returned from 182 sent out. 75% of the returned questionnaires were answered by the Principal Contractors (PC) and the remainder by Specialist Contractors (SC). The findings from the questionnaire helped to determine which sub-factors were to be included in SPMT (see Chapter 7).

5.2.3 Questionnaire Construction (see Appendix 5.1)

Section A

This section of the questionnaire starts with some general information questions used to identify the source and provide a useful contact point for clarifying queries about any given answers. This section includes the company address, position, working experience and construction sector where experience gained.

Section B

Section B was dedicated to establishing the relative importance of safety factors contributing to improve safety performance in construction. For this section, a closed format was chosen. Since the study is about the respondents' attitude towards the variables, a number of alternative answers were provided from which respondents were asked to select one or more.

De Vaus (1990) argues that the advantage of closed questions is that they do not discriminate against the less conversational and inarticulate respondents. Besides being easy to administer, closed questions are easy to answer. But it is necessary to put a lot of thought into developing alternative responses. The range must be exhaustive: a thorough range of responses must be listed to avoid biasing responses. The disadvantage of this approach is any spontaneity of response is removed.

A rating scale method was used to measure the opinions of the respondents. For the study, a five-point Likert's scale was chosen. For bipolar scales odd numbers have the advantage of offering a mid-point between the two poles. Some researchers prefer seven-point scales to five-point scales on the grounds they offer more scale position (and therefore discriminate more finely). According to Hoinville (1978) in practise however, five-point scales are probably the most frequently used, the easiest to understand and generally sufficient for most purposes. In Likert scaling, individuals are presented with a number of statements that appear to relate to a common theme; they then can indicate their agreement or disagreement on the scales chosen. The answer of each constituent question (often called items) is scored. For example in this study the range used was for IMPORTANCE and the range was from 'very important' to 'not important'. Using Likert scaling, the following ranking was determined and used:

5	= very important
4	= important
3	= average
2	= less important
1	= not important

5.2.4 Research Sample

The research method depends on the data required. In Survey I, the type of data required is cultural data that therefore require expert contribution. Bernard (2000) suggested that when collecting cultural data, then expert informants, not randomly selected respondents can be used. Therefore, the sample selected for this survey was selected from the 14 ECI Safety Task Force members. An agreement was reached during the bimonthly Safety Task Force meeting that all members would help distribute the questionnaire. Each member was given 13 sets of questionnaires to be distributed as follows:

Principal Contractor

Head Office-based Safety Director/ Manager	1
Site-based Safety Manager/Officer	1
Head Office-based Project Manager	1
Site-based Manager	1
Site supervisor	1

Specialist - contractor (x 2)

Head Office-based Safety Director/ Manager	1
Site-based Safety Manager/Officer	1
Site-based Manager	1
Site supervisor	1

A total of 182 questionnaires were sent out and the response rate was 35%. A higher response rate had been expected due to the simple and straightforward format of the questionnaire. A more disappointing result was from the Specialist-contractors.

5.3 SURVEY II

5.3.1 Expert Opinion

After identifying nine factors and 57 sub-factors from Survey I, an extensive study was carried out to identify and list out the indicators for each sub-factor. This task was managed through literature reviews, suggestions from Survey I and existing measurement systems. The sample of the questionnaire is given in Appendix 5.2. Table 5.1 lists out the number of sub-factors and indicators developed for the experts to evaluate.

In order to determine the set of indicators, a method was needed that would give reliable and fast answers. The method used knowledge elicitation techniques by experts in safety issues.

Table 5.1 – Lists of sub-factors and indicators for SPMT

Factors	Sub-factors	Indicators
Management (HQ)	6	29
Management (Site-office)	8	50
Supervision	5	22
Construction Engineering Control	6	34
Housekeeping	5	31
Training	6	47
Communication	8	27
Safety Culture	8	41
Health	6	22
Total	58	303

5.3.2 Selection of Expert Group

Adler (1996) claimed that with a homogenous group of experts, good results could be obtained even with small panels of 10-15 individuals. Survey II used 10 experts from the ECI Safety Task Force. The selection of 'appropriate' experts must not only be because of personal preference. On the contrary, it must depend on the aims and context within which Survey II was carried out. Among the criteria are knowledge and practical management with the issues under investigation, the capacity and willingness of selected experts to contribute to the exploration of a particular problem and sufficient time dedicated to this exercise. It is important to ensure that experts selected will produce response, which are rather more meaningful than if just anyone filled out the questionnaire.

For this study the European Construction Industry (ECI) Safety Task Force members were chosen. The Task Force members are key safety personnel representing their organisation in the area of safety. There is no doubt about their credibility is the area of safety. Table 5.2 shows the experience of each member.

Table 5.2 – List of the experts participated in Survey II

Name /Company	Experience
Dave Stewart Foster Wheeler Energy Ltd, UK	• Manager Construction Safety & Industrial Relations. • Member of International Institute of Risk & Safety Management (MIIRSM). • Corporate HSE Managers role in Foster Wheeler Energy Ltd. (one of the Worlds largest Engineering & Construction companies). • Member of the ECI HSE Task Force, ECIA (Engineering Construction Industry Assoc.). • HSE Committee, & Employers Representative on the NJC (National Joint Council for the Engineering Construction Industry) Safety Committee for four years. • 20 years experience in petrochemical sector.
Bill McGillivary Brown and Root Aberdeen, UK	• Director Production Services (1995-present) • Production operations manager at Shell UK exploration and production (1987-1994). • Head of safety & environmental affairs for Shell UK. • Project manager and head of engineering & technical services. • Head of field/construction at Brent fields. • 30 years experience in construction industry. • Chairman of ECI Safety task Force
Keith Rendel M.W.Kellogg Ltd	• Company Manager, Health, Safety and Environment (1997-present) • Construction Health and Safety Manager (1997) • National health and safety Manager at Daewoo cars Ltd (1995-1997) • Safety and Loss Manager at Quaker Oats Ltd (1994-1995) • Member of the Institute of Risk & Safety Management • Associate Member of the Institute of Occupational Safety and Health • 14 years experience in safety matters
Trevor Thompson Kvaerner Process UK Ltd	• Senior Safety Superintendent for Construction (1994–present) • Project Construction Safety Officer at British Gas (1993-1994) • Project Safety Officer at Philips Petroleum Co (1992-1993) • Safety Officer at John Brown (1990-1992) • Project Safety Officer at BP (1987-1990) • Project Safety Advisor at Arco/Philips (1988-1987) • Safety Officer at Amoco (1986-1988) • Safety Officer at Brown & Root Offshore (1984-1985) • Safety Officer at Technip Geoproduction (1984-1984) • Member of the Institute of Risk & Safety Management • Associate Member of the Institute of Occupational Safety and Health • Deputy Chair of the ECI Safety Task Force
Ray Canning Taylor Woodrow	• Construction Director with corporate responsible for health and safety • More than 30 years experience in construction industry
Dr Carsten Mink Lurgi Oel Chemie GmbH	• Head of Health, Safety and Environmental at Lurgi oel Chemie GmbH (1998-present) • Health, Safety and Environmental Manager at Lurgi oel Chemie

	GmbH (1995-1998) • Safety Engineer at Lurgi AG (1993-1995) • Safety Advisor at University of Technology Darmstadt, Germany (1989-1993)
Roy Greenslade AMEC Process and Energy Ltd.	• Manager of Health, Safety and Environmental • Job description: To establish, maintain and co-ordinate activities with the company that will reduce or eliminate workplace incidents, minimise the impact of activities on the environment and ensure the health and security of personnel, facilities, equipment and materials. To ensure achievements in health safety and environment and compliance with national, European and local government legislation.
Dirk Hessing ABB Lumus Global	• Manager Safety, Health, Environmental and Welfare Europe at ABB Lummus Global (1993-present) • Safety Manager at ABB Lummus (1991-1993) • European Engineering & Construction Service (1982-1993)
Ian Burgess Alstom Automation	• Safety and Environment Manager at Alstom Automation Ltd (1993-present) • Manufacturing Manager at GEC Alsthom Els Ltd (1988-1993)
Terry Skinner National Power	• Site manager responsible for health and safety

5.3.3 Why Expert Opinion?

There are four techniques that can be considered besides expert opinion for this study specifically aimed at multiple experts. The methods are brainstorming, consensus decision-making, nominal technique and Delphi Method. Tomlinson (1994) discusses all these four techniques.

Brainstorming

Brainstorming is a technique that encourages the freewheeling discovery of new ideas and new approaches through interaction between two or more people. The discussion takes place in a comfortable constructive group setting. In this kind of discussion, there is no 'right' or 'wrong' answer. The experts are briefed about the objective of the session before posing the problem. The experts are either asked to call out ideas as they occur to them or participate in turn. The facilitator or knowledge engineer records all decisions.

The problem with this technique is getting all experts together at one time and it is too time consuming. It is only suitable for experts who have the time and convenience to attend the session.

Consensus decision-making

Consensus decision-making uses a workshop that requires the experts to get together like brainstorming except they will have to vote for a decision. In Round 1 each expert will have three votes, but only one vote can be use for each solution. The options with less than a certain number of votes are deleted. In Round 2, the experts have two votes instead. The rounds will remain until two options remain. During the last round, each expert votes for the final options. Once the choice is made, a discussion period ascertains everyone's agreement with the choice. This technique, like brainstorming, requires all experts to be present at one meeting. Unlike brainstorming this method will be more fruitful by reaching an agreed decision.

Nominal group technique

This technique which is administered to a group of experts considering a single specific task at each meeting. This technique requires strong involvement and interaction of the group as a whole. It requires the group to write down their ideas about the problem, have a round-robin feedback from the group. Lastly, individuals vote on the priority idea with the group decision being mathematically derived from rank ordering or ratings.

Delphi Method (DM)

The objective of most Delphi applications is the reliable and creative exploration of ideas or the production of suitable information for decision-making (Adler 1996). DM is based on the structure for collecting and distilling knowledge from a group of individuals as a whole, to deal with a complex problem (Adler 1996, Tomlinson 1994).

Adler (1996) states that DM is most suited to gathering information from experts who are diversely located in contrast to the other methods. All the three methods described previously require the experts to be present in the same room together discussing the problem. DM requires at least two phases of surveys. The first phase is the exploration phase and the second phase is a more finer focus of the response.

However, Survey II only had one phase due to the nature of the questionnaire that required a lot of time and effort. As Table 5.1 indicated, there are 303 indicators for each expert to go through, rank and give suggestions to improve the indicators. Since the information gathered from this Survey will go through another stage of validation process, one round of expert opinion was considered to be sufficient. Survey II was not possible to be carried out like a normal one on one interview for it could not have been completed in one sitting.

5.3.4 Questionnaire Construction (Appendix 5.2)

In Survey II, a combination of closed and open-ended questions was used. An open-ended approach was chosen for experts to put their comments about the indicators concerned. These comments were important to be considered for developing the indicators of SPMT. Since the experts were known, it was not necessary to include the general information section. The panellist was given an explanation of what each score meant. The five-point rating scale still applied in this section chosen based on a study by Adler (1996). He had used this rating to determine the important factors were chosen. The scale was as follows: -

5 = very important

4 = important

3 = moderately important

2 = unimportant

1 = most unimportant

It was a real challenge to carry out Survey II. Even though four experts had declined to participate. the other ten had participated positively. They sacrificed their time and effort to ensure that the important indicators were included in SPMT. The participants were very helpful and provided good comments and feedback to the questionnaires which helped to develop SPMT.

5.3.5 Research Sample

The sample selected is a non-probability sample using quota sampling. Quota sampling is about choosing a set of key informants – people who are knowledgeable about a particular subject or domain. This set of people best represent the variation in domain of a culture (Cramer 1998, Black 1999, Bernard 2000). In Survey II, the set of key informants chosen was from the ECI Safety Task Force members. This cost-effective approach adopted will represent the safety experts in the industry. A briefing was carried out before distributing the questionnaires. The briefing explained the format of the questions and the expectations from it. All present had agreed to participate. So 14 questionnaires were distributed to the members. The time scale was extended due to the lengthy questionnaires. 10 responded and the other 4 declined to participate. The response was very good despite the time and length of the questionnaires.

5.4 SURVEY III

Survey I and Survey II identified all the critical and important SCMs and indicators that would form the basis of SPMT. The indicators identified in Survey II needed further validation of their importance through a bigger and wider sample. These stages not only prove that only important and critical data were chosen to form SPMT, but also that the information went through a vigorous process of validation. The following process was adopted for Survey III.

5.4.1 Pilot test

It was still necessary to pilot test Survey III as it used a different survey technique and questions. 10 professionals in the construction industry participated in the pilot test. These pre-test respondents were asked to critique the questionnaire in general, and the items on various scales in particular. The feedback received was very positive and encouraging. Important comments were forwarded to clear ambiguity and vagueness.

Among the changes made was replacing the word subfactors with safety control measures (SCM). This was really a good suggestion and gives a better meaning to the term. The weighting approach in Section 3.0 of the questionnaire was changed to ranking. Some unclear questions were also changed.

5.4.2 Main survey

The main survey was carried out to validate the importance of the chosen SCMs and indicators identified in Survey I and Survey II. The feedback demonstrated that the variables that form SPMT are essentially important and critical.

Questionnaires were sent out to the respondents from UK and mainland Europe. Letters and telephone follow-ups were used and ultimately, a 50% response was received from the UK contractors while only 13% response was received from other European contractors. A postal survey was used, as the purpose of the survey was clear enough to be explained in a few paragraphs. The scheme of questions was not over-elaborate and only required the respondents to rank the importance of the indicators.

5.4.3 Questionnaire Construction (see Appendix 5.3)

Hoinville et al (1978) claims that a good questionnaire has to be designed specifically to suit the aim of the research and the nature of the respondents. They added that the questionnaire needs to be clear, unambiguous and uniformly workable. Its design must minimise potential error from respondents. The most important to consider is that since people's participation in a survey is voluntary, a questionnaire has to help in engaging their interest, encouraging their corporation and eliciting answers as close as possible to the truth.

Hoinville et al outlined four main design considerations, namely:

- questions have to be designed so that they are easy for respondents to understand and answer accurately and clearly;
- questions have to be clear, unambiguous and useful. using a simple language, short questions, avoiding negative questions and bias questions;
- questions must be easy to administer;
- questions should be constructed so that they are easy to analyse; and

- the flow, structure and length of the questionnaire should encourage and keep the respondent's interest.

Section 1

Section 1 starts with the general information. This section finds out about the nature of the business of each respondent and years of experience in the industry.

Section 2

In this section, the respondents were required to state the company safety performance self-assessment. This section provided information about the approach adopted, types of system applied, frequency of assessment and other valuable information from existing safety performance self-assessments. This section will help establish the pattern of existing self-assessment in the industry.

Section 3

This section requires the respondents to rank in order of importance the three groups of SCMs. The SCMs were divided into three main groups that form a good safety system: that is hardware (engineering system and control for plant and equipment); software (management, work system and procedures); and people (behaviours).

Section 4

Section 4 covers weighting the indicators. This section also applies a five point ranking scale, but omitting the middle alternative and measure of intensity. Robson (1993) cited that middle alternative encourages non-committal responses. According to him, 20% of respondents may use the middle category, but it appears that its inclusion or exclusion does not affect the relative proportions of those actually expressing opinions. The respondents using the middle category are those without strong feelings on the issue and a suggested strategy for this sort of survey is by not using a middle alternative. Since all the SCMs and indicators were identified as important safety factors from Survey I and Survey II, there should be strong agreement to it. Therefore, the ranking scale used did not permit any 'middle response'.

5.4.4 Research Sample

Survey III uses purposive sampling. This is a strategy in which particular settings, persons or events are selected deliberately in order to provide important information that is not available from other samples (Bernard 2000). This survey required active safety personnel to rate the level of importance for the SCMs and indicators. Survey III was also aimed at a wider sample than the previous surveys. The sample chosen were from the top UK and European mainland contractors for 1998. This time there was no involvement of the ECI Safety Task Force. The response from the UK contractors was very encouraging with a 50% response rate that was beyond expectation. On the other hand, the poor response from the European countries (13%) may be due to the language barrier. Another factor may be because the European questionnaires were not addressed personally to named Safety Officer or Safety Director but to the General Manager, Director or even Chairman, based on the information available (CE 1999).

The reason for selecting the top UK and European companies is due to their experience, established business practices, specialisation on specific projects and expertise acquired from developing many projects.

5.5 SUMMARY

1. The instrument used for Survey I and Survey III was a postal survey. The questionnaires were designed to be as manageable as possible, easily understood, not too time consuming and precise.

2. Survey II required expert opinion and involvement. The input required for Survey II requires time to accomplish. Only by personally approaching the experts in safety, informing them of what to expect from them could this task have been accomplished.

3. The involvement of the ECI Safety Task Force members was very extensive. Besides the ECI members, the top UK and European contractors for 1998 were also included in the sample for Survey III.

4. The response rates were as follows:

   Survey I
   - Principal Contractor 67% (47/70)
   - Specialist Contractor 14% (16/112)

   Survey II
   - Expert opinion 10 experts from ECI Safety Task Force

   Survey III
   - UK contractors 51% (31/61)
   - Europe contractors 12% (11/90)

5. Survey III showed that almost all the SCMs and indicators chosen from Survey I and Survey II were considered to be important. It was really difficult to delete any variables. The number of variables too had to be considered in order to ensure that SPMT would be manageable. That was why some of the variables were combined and redefined.

CHAPTER 6

METHODS OF ANALYSIS FOR DEVELOPING SAFETY CONTROL MEASURES

6.1 INTRODUCTION

This chapter outlines the methods used to analyse all the information gathered through the surveys to determine the direction of the research. Analysis determines the significance of the information towards the study. Analysis also summarises the data that highlights main trends and differences in the most appropriate manner. In this research analysis was used to compare, to measure the degree of importance and to establish the current trend with regard to safety performance.

Normal statistical tools were used for analysing Survey I, Survey II and Survey III. However in order to establish the degree of importance for each SCM in Survey III, the group decision making using fuzzy majority introduced by Lotfi Zadeh in 1965 was used. To date, the application of fuzzy set theory in construction has not been fully explored. In his study, Abdul Majid (1997) reported that the research areas that are using fuzzy logic are such as project scheduling, tender evaluation and project risk. In general, most applications employed in construction management research focus on other subject areas, which include: pattern recognition; quantitative analysis; inferences and information retrieval. Nevertheless, fuzzy logic is widely used in electronic, manufacturing and household appliances. The following discussion is about the methods of analysis adopted for this research concentrating on the fuzzy majority approach.

6.2 GROUP DECISION MAKING WITH A FUZZY MAJORITY

Decisions are made today in increasingly complex environments. The use of expert opinions in various fields is necessary. In many decision-making settings, the theory of group decision making (social choice) can be used. Group decision-making consists of deriving a solution from the individual preferences over a set of options in questions. The solution should reflect what a majority of individuals prefer.

Though the above basic problem formulation seems extremely simple, maybe even trivial, it is certainly not. Kacprzyk (1993) reported that since its very beginning, group decision making has been plagued by negative results. Since the process of decision making, notably of group type, is centred on human beings, with their inherent subjectivity, imprecision and vagueness in the articulation of opinions, fuzzy sets have been used.

According to Kacprzyk (1993) one of the basic elements underlying group decision making is the concept of majority. Here the majority is used as a solution for an option best acceptable by the group as a whole, that is by most of its members since in no real situation it would be accepted by all. This approach is based upon an extension of the algebraic method, with the underlying truth drawn from the unit interval. This method uses the power of a fuzzy subset as a measure of cardinality (most importance). Before pursuing the approach further, an overview of fuzzy subset theory is given.

6.2.1 Overview of Fuzzy Logic

To understand how fuzzy systems provide superior information modelling, it is important to go back to its origin. As conceived by Lotfi Zadeh, the inventor of fuzzy logic, it provides a method of reducing as well as explaining system complexity
"..........that the conventional quantitative technique of system analysis are intrinsically unsuited for dealing with humanistic systems or for that matter, any system whose complexity is comparable to that of the humanistic system. The basis for this contention rests on what might be called the principle of compatibility. Stated informally, the essence of this principle is that as the complexity of a system increases, our ability to make precise and yet significant statements about its behaviour diminishes until a threshold is reached beyond which precision and significance become almost mutually exclusive characteristic." (Dubois et al 1993 pp.2)

Zadeh advocates an alternative approach

"........based on the premise that the key elements in human thinking are not numbers, but labels of fuzzy sets, that is, classes of objects in which the transition from membership to non-membership is gradual rather than abrupt. Indeed the perverseness of fuzziness in the human thought process suggests that much of the logic behind human reasoning is not the traditional two-valued or even multi-valued logic, but a logic with fuzzy truths, fuzzy connectives and fuzzy rules of inference".

In this view of modelling complex systems, the underlying mechanics are represented linguistically rather than mathematically. Zadeh makes a case for human reasons to be considered not in terms of discrete symbols and numbers but in term of fuzzy sets. The transition from one category – concept, idea or problem state – to the next is gradual with some states having greater or less membership in the one set and then another.

The idea of fuzzy set

This section provides a brief explanation of some of the basic concepts of fuzzy set theory and fuzzy logic before embarking on the application of linguistic quantifiers and fuzzy majority. Klir et al (1988) explain Zadeh's concept in detail. Fuzzy sets are actually functions that map a value that might be a member of the set to a number between zero and one indicating its actual degree of membership. A degree zero means the value is not in the set (non-membership) and a degree one means that the value is completely represented (full membership).

As an example, Klir et al (1988) explain the approach of describing the weather today not in terms of the exact percentage of cloud cover which would be too complex, but rather as to say how 'sunny' it is. In order for a term such as 'sunny' to accomplish the desired introduction of vagueness, it is not right to use 0% cloud cover. Its meaning is not totally arbitrary. A cloud cover of 100% is not 'sunny' and neither is a cloud cover of 80%. The intermediate states, such as 10 or 20 % cloud cover as 'sunny' can be accepted. But where is the line drawn? If, for instance any cloud cover of 25% or less is considered 'sunny', does it mean that a cloud cover of 26% is not? This is clearly unacceptable since 1% of cloud could hardly seem like a distinguishing characteristic between 'sunny' and 'not sunny'. A qualification can be added that any amount of cloud cover 1% greater than a cloud cover already considered 'sunny' (that is 25% or less) will also be labelled as 'sunny'. This definition will eventually lead to the acceptance of all degrees of cloud cover as 'sunny', no matter how gloomy the weathers looks! In order to resolve this paradox, the term 'sunny' may introduce vagueness by allowing some sort of gradual transition from degrees of cloud cover that are considered to be 'sunny' and those that are not. This is precisely the basic concept of fuzzy set.

A fuzzy set can be defined mathematically by assigning to each possible individual in the universe of discourse a value representing its grade of membership in the fuzzy set. This grade corresponds to the degree to which that individual is similar or compatible with the concept represented by the fuzzy set. Thus, individuals may belong in the fuzzy set to a greater or lesser degree indicated by a larger or smaller membership grade. These memberships are very often represented by real number values ranging in close intervals between 0 and 1. Thus, a fuzzy set representing the concept of 'sunny' might assign a degree of membership of 1 to a cloud cover of 0%, 0.8 to a cloud cover of 20%, 0.4 to a cloud cover of 30% and 0 to a cloud cover of 75%. These grades signify the degree to which each percentage of cloud cover approximates our subjective concept of 'sunny' and the set itself models the semantic flexibility inherent in such common linguistic terms. Because full membership and full nonmembership in the fuzzy set can still be indicated by the values of 1 and 0, respectively, we can consider the crisp set to be a restricted case of the more general fuzzy set which only these two grades of membership are allowed. The crisp set is defined in such a way as to dichotomise the individuals in some given universe of discourse into two groups: members and non-members. A sharp, unambiguous line exists between the members and non-members of the class or category represented by the crisp set.

Fuzzy sets naturally appear in no-strict specifications. It may be soft constraints or flexible requirements for which slight violations can be tolerated. Fuzzy membership functions will depend on the context in various ways. First, the universe of discourse (i.e. the domain of the membership function) has to be defined (e.g. tallness is not the same thing for a man or for a tree). Second, it may depend on other classes which are used to cover the domain. For instance, with respect to a given domain, 'small' does not mean exactly the same thing if the remaining vocabulary includes only 'large' or is richer and contains both 'medium' and 'large'. Lastly, a fuzzy membership funtion may vary from one person to another.

Fuzzy sets can be interpreted in different ways, the most common view is to see membership functions as a way of assessing a degree of satisfaction or preference for the different elements of interpretation. The most popular application of fuzzy control systems, especially in Japan, are of industrial applications in domestic appliances, process control and automotive systems. The area of information systems, especially information retrieval and database management, can also benefit from fuzzy set methodology. Regression analysis takes advantage of this similarity naturally associated with fuzzy sets and has been used mainly in clustering analysis. As for data analysis, application to pattern recognition and classification take advantage of a fuzzy specification of features in class dispersion. Also fuzzy set aggregasion techniques or fuzzy expert rules can improve the classification method. Neural network techniques are now used for fuzzy set membership elicitation, especially in fuzzy control for inducing rules from observations. Lastly, fuzzy sets find natural applications in the processing and analysis of grey-tone digitised pictures.

Fundamental principles

A fuzzy set is generally assumed to be imbedded in a nonfuzzy universe of discourse, which may be a collection of objects, concepts or mathematical constructs. For example, a universe of discourse, U may be a set of real numbers; the set of integers 0, 1, 2, ...100; the set of all residents in a city; the set of all civil engineering students; etc. Universes of discourse are usually denoted by the symbols U, W, V, ..., with or without subscripts and/or superscripts.

A fuzzy subset A of a universe of discourse U is characterised by a membership function $\mu_A : U \rightarrow [0, 1]$ which assosiates with each element u of U a number μ_A (u) in the interval [0, 1], with $\mu_A\ (u)$ representing the grade membership of u in A. The support of A is the set of points in U at which $\mu_A\ (u)$ is positive.

For example demonstrated by Dubois et al (1984), let the universe of discourse be the interval [0, 100], with u intepreted as 'age'. A fuzzy subset of U labeled 'old' may be defined by a membership function such as

$$\mu_A(u) = 0 \qquad \text{for } 0 \le u \le 50$$

$$= \left(1 + \left(\frac{u-50}{5}\right)^{-2}\right)^{-1} \quad for 50 \le u \le 100$$

In this case, the support of 'old' is the interval [50, 100], the height of 'old' is effective unity, and the crossover point of old is 55. It should be remarked that in many applications the grade membership of $\mu_A(u)$ may be interpreted as the degree of compatibility of u with the concept represented by A. for example, in the case of fuzzy set 'old' as defined by (1), the degree to which the numerical age 60 is compatible with the concept of 'old' is $\mu_{old}(60) = 0.8$

Simple operation of fuzzy subsets

1. Inclusion

   If $\forall u \in U;\ \mu_{\underline{A}}(u) \le \mu_{\underline{B}}(u)$ then $\underline{A}$ is included in $\underline{B}$.

   Denoted by $\underline{A} \subset \underline{B}$. Here, U is a set and M is its membership set, $\underline{A}$ and $\underline{B}$ are two fuzzy sets of U.

2. Equality

   If $\forall u \in U;\ \mu_{\underline{A}}(u) = \mu_{\underline{B}}(u)$, then $\underline{A} = \underline{B}$.

3. Complementation

   If $\forall u \in U;\ \mu_{\underline{B}}(u) = 1 - \mu_{\underline{A}}(u)$, then $\underline{A}$ and $\underline{B}$ are complementary. Denoted $\underline{B} = \bar{\underline{A}}$ or $\bar{\underline{A}} = \underline{B}$.

4. Intersection

   Let $\underline{A}$ and $\underline{B}$ be two fuzzy subsets of U, intersection is defined $\underline{A} \cap \underline{B}$. The largest fuzzy subset contained at the same time in $\underline{A}$ and $\underline{B}$ is

   If $\forall u \in U;\ \mu_{\underline{A} \cap \underline{B}}(u) = MIN(\mu_{\underline{A}}(u), \mu_{\underline{B}}(u))$

5. Union

   We define the union $\underline{A} \cup \underline{B}$. The smallest fuzzy subset that contains both $\underline{A}$ and $\underline{B}$ is: If $\forall u \in U;\ \mu_{\underline{A} \cup \underline{B}}(u) = MAX\ (\mu_{\underline{A}}(u)\ ,\ \mu_{\underline{B}}(u))$

6. Disjunctive sum

   The disjunctive sum of two fuzzy subsets is defined in terms of union and intersections:

   $\underline{A} \oplus \underline{B} = (\underline{A} \cap \underline{\overline{B}}\ ) \cup (\ \underline{\overline{A}} \cap \underline{B})$

7. Difference

   The difference is defined by relation $\underline{A}$-$\underline{B}$= $\underline{A} \cap \underline{\overline{B}}$ *where* $\underline{A} - \underline{B} \neq \underline{B} - \underline{A}$

The total allowable universe of value is called the domain of the fuzzy set. The value of the domain can be both positive and negative. For this research, the domain applied is IMPORTANCE and have a domain that constitutes from 0-10. A linguistic variable also carries with it the concept of fuzzy qualifiers. These qualifiers change the shape of fuzzy set in predictable ways and function on the same fashion as adverbs and adjectives in the English language. For the research, five ratings levels will be used that are:

- Absolutely important
- Very important
- Important
- Slightly important
- Little importance

6.2.2 Linguistically quantifier based upon power of cardinality

Basically, these liguistic majorities have tried to formalise human rational behaviour. Kacprzyk (1993) argues that it has been deemed natural that this rationality boils down to the maximation of some utility (value) function, or some expected utility function in case of uncertainty; such functions have been shown to exist providing the preferences satisfy some 'natural' conditions. This approach makes the decision making problem virtually equivalent to optimisation. It has been popular and often successful, partly due to the availability of powerful mathematical means.

Since the process of group decision making, notably of group type, is centered on human beings, with their inherent subjectivity, imprecision and vagueness in the articulation of opinions etc., fuzzy sets have been used in this field for a long time. Fedrizzi et al (1993) argued that the ability to accommodate a fuzzy majority in concensus formation models should help make them more human consistent hence easier to implement.

To summarise the above considerations, a possibility to accommodate a less rigid 'soft' majority (as say, an equivalent of widespread agreement in the above citations) would certainly help make group decision models more human consistent. Natural manifestation of 'soft' majorities are called linguistic quantifiers e.g. 'most', 'almost all' more than 50%' etc.

Drawing upon Zadeh's concept, Yager (1992a) described three important classes of linguistic quantifiers:

i. Monotone (increasing);
ii. Anti-monotone (decreasing); and
iii. Unimodal.

Definition

i. A quantifier Q is called monotone if all $r_2 < r_1$ it is the case that

$$Q(r_1) \geq Q(r_2)$$

ii. A quantifier Q is called anti-monotone if all $r_2 > r_1$ it is the case that

$$Q(r_2) \geq Q(r_1)$$

iii. A quantifier Q is called unimodal if there are two, not necessarily distinct, points $a,b \in [0,1]$ where $a<b$ such that

i. for all r, $a \leq r \leq b$

$Q(r_1) = 1$

ii. for all $r_4 < r_3 < a$

$Q(r_4) \geq Q(r_3)$ (its monotone)

iii. for all r, $r_4 > r_3 > b$

$Q(r_4) \leq Q(r_3)$ (its anti-monotone)

Most practically used quantifiers fit into one of these three categories. The following example is given by Yager (1992a) covering each of the three classes:

i. monotone : 'at least r', 'all', 'most', 'almost all';
ii. anti-monotone: 'few', 'less than r'; and
iii. unimodal: 'about r', exactly r', 'not none'.

The three classes of quantifiers, especially the monotones, play an important role in the representation of multicriteria decision functions as well as in the representation of rules in expert systems. The following example illustrated by Yager explains it further: Consider a medical expert system which has rules for diagnosing various diseases. Let A_1............A_n be a collection of symptoms associated with a particular disease D. In many cases, the occurrence of the disease D does not mandate that all symptoms be present but may only require that some portion of them be present. Thus, rather than using the rule

"If A_1, A_2 .... and .A_n then D"

this following rule is more appropriate:

"If most of A_1, and A_2 .... and .A_p then D"

However the selection of the quantifier is purely a subjective choice of the decision-maker. Yager and Zadeh (1984,1992b) proposed some fuzzy-logic-based calculi of linguistically quantified propositions that makes it possible to handle fuzzy linguistic quantifiers. According to Fedrizzi et al (1993) these calculi have been applied to derive new solutions concepts in-group decision making which have been implemented in a decision support system for consensus. A quantified proposition is exemplified by 'most experts are convinced' or 'almost all good cars are expensive'. Zadeh states that the conventional two-valued predicate calculus makes it possible to determine the truth of a quantified proposition for crisp quantifiers, say 'all' and 'at least one' (Kacprzyk 1986). The truth of such propositions may be found by using the following calculus based upon fuzzy logic (Kacprzyk 1986).

A general form of linguistically quantified statement is

$$QY\text{'s are } F \qquad (1)$$

Where,

Q is a linguistic quantifiers (e.g. all, at least one, most),

Y is a class of objects (e.g. experts), and

F is some property (e.g. convinced)

We may assign to the particular *y's* (objects) a different *importance* (relevance, competence), B, which may therefore be added to (1) yielding

$$QY\text{'s are } F$$

say, "most (Q) of the important (B) experts (y's) are convinced (F)"

The main problem here is how to find the truth of such linguistically quantified statements, i.e. truth (QY's are F) or truth (QBY's are F) knowing truth (y is F), $\forall y \in Y$.($\forall$ = universal quantifier).

In Zadeh's method, a fuzzy linguistic quantifier Q is assumed to be a fuzzy set defined in [0,1]. For instance, Q = 'most' may be given as:

$$\mu_{\text{'most'}}(x) = \begin{cases} 1 & for x \geq 0.8 \\ 2x - 0.6 & for 0.3 < x < 0.8 \\ 0 & for x \leq 0.3 \end{cases} \qquad (2)$$

This may be interpreted as follows: if at least 80% of some elements satisfy a property, then most of them certainly (to degree 1) satisfy it, when less than 30% of them satisfy it (satisfy to degree 0), and between 30% and 80% – the more of them that satisfy it, the higher the degree of satisfaction by most of the elements (Kacprzyk et al 1992). For this research, the proportional quantifiers 'most' will be used as they are more important for modelling a fuzzy majority than an absolute quantifiers (e.g. about 5, much more than 10, etc.).

The property F is defined as a fuzzy set in Y = $\{y\} = \{y_1, \ldots\ldots y_n\}, F \subseteq Y$, and $\mu_F(y_i)$ is the truth of "y_i is F'', i = 1.....,p.

The problem is to find truth (*QY's* are *F*) knowing all truth (y_i is *F*), i = 1.....,p. Truth (*QY's* are *F*) is now calculated using the non-fuzzy cardinalities called ΣCounts, of the respective fuzzy sets in the following two steps (Kacprzyk et al 1992):

Step 1:

$$r = \frac{\Sigma count(F)}{\Sigma count(Y)} = \frac{\Sigma count(F)}{p} = \frac{1}{p}\sum_{i=1}^{p} \mu_F(y_i) \tag{3}$$

Step 2:

$$\text{truth } (QY\text{'s are } F) = \mu_Q(r) \tag{4}$$

In case of importance, B = 'important' ⊆ Y, and μ_B $(y_i) \in [0,1]$ is a degree of importance of y_i: from 1 for definitely important to 0 for definitely unimportant, through all intermediate values.

Step 1

$$r' = \frac{\Sigma\text{Count (B and F)}}{\Sigma\text{Count (B)}}$$

$$r = \frac{\sum_{i=1}^{p} (u_B(y_i) \wedge u_F(y_i))}{\sum_{i=1}^{p} u_B(y_i)} \tag{5}$$

Step 2

truth ($QBY's$ are F) = $\mu_Q(r')$

where '$\wedge$' is maximum, i.e. $a \wedge b$ = max (a,b). For this research, all the experts have equal importance, therefore this approach of importance is not applicable.

Example

If Y = 'experts = $\{John, Bob, Bill\}$, F = 'convinced'

= 0.1/John + 0/6/Bob + 0.8/Bill, and Q = 'most' given by (2), then

r=1/3 (0.1 + 0.6 + 0.8)

= 0.5

and

truth (most of experts are convinced)

truth ($QY's$ are F) = μ $_{\text{'most'}}$ (0.5)

= (2 x 0.5) – 0.6

= 0.4

Thus the consistency of the particular definition of F with the proposition 'most of experts are convinced' is 0.4 and is categorised as low.

This method appears to fit best for the research because only the importance of the critic is measured. There has been criticism about the approach such as not being fuzzy enough which may lead to unacceptable results. Due to this, Yager (1993) introduced the use of ordered weighted average (OWA) operators for the representations of fuzzy linguistic quantifiers. OWA is applied only when there is more than one alternative with few decision-makers and different levels of importance. Since this research does not have to choose any alternatives, just measuring of importance, Zadeh's approach seems best suited.

6.3 STATISTICAL TEST

Once the data have been collected, they have to be analysed. The factors, which affect how the data are analysed, are:

- the number of variables being examined;
- the level of measurement of the variables, and
- whether the data is for descriptive or inferential purposes.

How the data is analysed depends on what is to be determined. Before further discussion on the methods chosen for the analysis, a brief explanation on the level of measurement used to collect data is explained below.

6.3.1 Level of Measurement

It is usually generally helpful to classify all data as being on a nominal, ordinal, interval or ratio scale. Data that are nominal include such category as sex of respondents, town, country and others. Data that are of an ordinal scale indicate some ranking such as social class, grade, position in management hierarchy. While one category may be higher or better than another, the difference between each adjoining pair may not necessarily be the same. Data on an interval scale are numerical and intervals between numbers mean the same thing, but zero has no meaning. Thus the score of 90 and 95 should mean the same as the difference between 105 and 110 for an IQ test. Data on a ratio scale are again numerical data where the interval on the scale is equal but now zero does have a meaning.

For this study ordinal scales were used. All data collected used a Likert scale or ranking of the score. Likert scaling is a popular approach to the creation of multiple-item measure. The Likert technique produces an ordinal scale that generally uses non-parametric statistics. The scale is highly reliable when it comes to rough ordering of people with regard to a particular attitude or attitude complex (Black 1999). The score includes a measure of intensity as expressed on each statement. With Likert scaling individuals are presented with a number of statements which appear to relate to a common theme; they then can indicate their agreement on the level of importance on a five-point average. The answer of each constituent question (often called item) is scored, for example from 1 (Not Important) to 5 to (Very Important). An example of the scaling is as follows used in Survey I:

Very Important	5
Important	4
Average	3
Little Importance	2
Not Important	1

6.3.2 Statistical Significance

Besides the scale used to measure the variables, the objective of the analysis will finally determine the statistical method used. The objective was to establish the impact of individual factors for each sub-factor in terms of their relative ranking of importance and if there is any association between the principal contractors' (PC) and specialist contractors' (SC) response. The ranking was based on the average index, which will be discussed further in this section.

There is a need to state the expected outcomes of inferential statistical research in terms of the null hypothesis that there will not be any statistical difference. In other words, it is expected that any difference, changes, or relationship found will be attributable to chance alone. Even if the null hypothesis is rejected, it only means that the difference or occurrence witnessed probably did not occur by chance alone. This traditional probability level has been set at a critical level of 5%. This basically means that if a statistical test says that the probability of this event occurring by chance alone is less than 0.05 or five times out of hundred, then it probably did not occur as a random event. Black (1999) stated that, at this level, there is something probably influencing the event, or at least the event has occurred as the result of some external influence other than natural random fluctuation. The convention of adopting the 0.05 probability level as a cut-off point for determining the statistical significance of a finding is arbitrary since there is always the probability that any result is due to chance.

With reference to the research, three things can be found out if PCs differ in their perspectives. There are three possible answers to these questions:

1. PCs may be more perceptive than SCs;
2. there may no difference between them; or
3. PCs may be less perceptive than SCs.

The above are three different expectations or hypotheses about what the answers might be. Therefore not expecting any difference is chosen and is known as the null hypothesis which is discussed below. For this study, a significance value of 0.05 was adopted.

6.3.3 Testing the Null Hypothesis

For normally distributed traits, those that produce sample means out in either of the trails of a distribution of sampling mean are highly unlikely. Social science researchers commonly accept events which occur less frequently than 5% of the time are unlikely to have occurred by chance alone and consequently are considered statistically significant. To apply this to a normal distribution would mean that 5% must be divided between the top and the bottom levels of distribution with 2.5% for each. Two ranges of sample means that would be considered statistically significant, and result in the rejection of the null hypothesis, since they probably did not occur as part of the natural chance variation in the means.

To measure if there is any association between PC and SC, a null hypothesis needs to be stated. The null hypothesis simply states that 'no significant difference' is expected between what will be obtained and what would happen by chance alone. A null hypothesis focuses the attention on stating the implication of the proposed relationship among variables in terms that can be resolved by statistical instruments. For this study the null hypothesis is that there is no difference in agreement between the PC and SC. Both PC and SC agree on the important safety control measures that affect safety performance on site. A significance value of 0.05 or 5% is adopted and if the calculated value is less than 0.05, then the null hypothesis is rejected. Otherwise, the alternative hypothesis is accepted.

When the hypothesis is non-directional in the sense that we do not predict what the results will be, a two-tailed probability level, which takes into account both ends or tails of the probability distribution, is used. For example the proportion of PC and SC differed from that in the population but did not have any expectation about the way in which it differed. A one-tail probability is half that of two-tailed probability level, statistical significance is more likely to be obtained when the direction of hypotheses is stated. However one-tail probability level can only be used when the direction the results will take has been specified before the data are analysed. If the direction of the results is not predicted before the data are examined, the two-tailed probability level has to be employed. For this study a one-tail probability level is employed.

6.3.4 Non-parametric Correlation Tests

Two prominent methods available for this study are Kendall tau (τ) and Spearman rho (ρ) (Baryman et la, 1994; de Vaus, 1990). Both these methods involve ranking people on each variable and then comparing people's relative position on the two variables. Both Kendall's tau and Spearman's rho are normal correlation coefficients. They range between 0 to 1, can have a negative sign, and only measure linear relationships and are symmetrical.

According to Cramer (1998) there is not much difference between the two methods except where the ratio of cases to categories is smaller (i.e. fewer people and 'larger' variable) when Spearman's rho can be more appropriate.

The variable under study may be ranked by both groups i.e. the variables identified for each group of factors was ranked using the Likert five-point scaling. There were N variables as an object ranked by the respondents using the ordinal scale and the average ordinal scale. These were computed using the formula explained in the following section. The rank was based on the calculated average ordinal scale or known as an average index and it was used as a measure of rank-order correlation to determine the correlation between PC and SC.

Rho is essentially the same as Pearson's product-moment correlation. Thus most straight forward way of calculating Spearman's rho is to carry out by simplifying the formula for the Pearson product-moment correlation coefficient r when the data are comprised of ranks. (Black 1999). If

$x = \mathrm{X} - \overline{\mathrm{X}}$ where $\overline{\mathrm{X}}$ is the mean of the scores of PC variables;

$y = \mathrm{Y} - \overline{\mathrm{Y}}$, where $\overline{\mathrm{Y}}$ is the mean of the score of the SC variables; an

d is the difference between the ranking of PC and SC.;

t is the statistical significance; and

the Pearson product-moment correlation coefficient is

$$r = \frac{\Sigma xy}{\sqrt{\Sigma x^2 \Sigma y^2}} \qquad (6)$$

in which the sums are over the N values in the sample. Now when the x's and y's are ranked, $r = r_s$, knowing that the data are ranking, we simplify equation (6) to yield the following expressions for Spearman's rank-order correlation coefficient:

$$r_s = \frac{\Sigma x^2 + \Sigma y^2 - \Sigma d^2}{2\sqrt{\Sigma x^2 \Sigma y^2}} \qquad (7)$$

$$r_s = 1 - \frac{6\sum_{i-1}^{N} d_i^2}{N^3 - N} \qquad (8)$$

$$t = rho \times \sqrt{\frac{N-2}{1 - rho^2}} \qquad (9)$$

If the value of r_s exceeds the critical value, that is 0.05, reject H_0 in favour H_1. The value of Spearman rank correlation coefficient can be in range of $+1 > R_s > -1$ and when the correlation is zero implies an absence of any correlation at all. If the value is nearly positive it indicates a strong correlation and a negative correlation indicates an opposite rank in between two respondent groups.

6.3.5 Average Index

To establish the ranks for all the SCMs in Survey I, Section B and Survey II, an average severity index was calculated. For example for Section 2.0, Survey I, the ratings used were as follows:

Very Important	5
Important	4
Average	3
Little importance	2
Not important	1

The above ratings were mainly used to determine the importance of the SCM put forward to both the PC and SC. The average index was calculated as follows (Marsh 1988):

$$\text{Average index} = \left[\frac{\sum_{i=0}^{4} a_i x_i}{4\sum_{i=0}^{4} x_i}\right] \text{ for five scale} \qquad (10)$$

Where a_i = constant expressing the weight given to i, x_i variables expressing the frequency of the response for i;

i = 1,2,3,4,5

x_1 = the frequency for very important

x_2 = the frequency for important

x_3 = the frequency for average

x_4 = the frequency for little importance

x_5 = the frequency for not important

where,

a_1 = 5

a_2 = 4

a_3 = 3

a_4 = 2

a_5 = 1

The results of each value of the average index or mean score were shown under the column of PC and SC mean in Table 7.1 – Table 7.9. Abdul Majid (1997) has used a discrete scale converted to a continuous index (average index) which can be split into discrete categories as follows:

Very High Importance	$4.50 \leq$ mean score ≤ 5.00
High Importance	$3.50 \leq$ mean score ≤ 4.50
Slightly Important	$2.50 \leq$ mean score ≤ 3.50
Average	$1.50 \leq$ mean score ≤ 2.50
Low importance	$0.50 \leq$ mean score ≤ 1.50
Very low importance	$0.00 \leq$ mean score ≤ 0.50

6.4 SUMMARY

1. Group decision making with fuzzy majority was considered to be the most suitable method to measure the degree of importance for each SCM and indicators. This method uses experts' opinion to establish the best acceptable solution by the group as a whole.

2. The use of fuzzy logic is suitable for uncertain or approximate reasoning that involved a human descriptive or intuitive thinking. The fuzzy domain used in the research was IMPORTANCE, which acted as a sensor to each question.

3. Solution concepts in group decision making under fuzzy majority was expressed by a fuzzy linguistic quantifier 'most' is applied for the research. It was important to ensure that a large consensus of the respondents agree with the SCMs and indicators chosen. This quantifier was used since 'most' represents majority for the best options decided by the experts as a whole. It was not appropriate to use the quantifier 'all' due to the fact that there won't be a 100% agreement in any decisions.

4. A quantified proposition used for the research was based upon fuzzy logic.

5. The fuzzy control becomes finer if more levels of ratings and the number of levels depends on the controlling requirement, either fine or coarse. For this research a five-rating scale was adopted.

6. The statistical method employed for this research was Spearman's rank correlation coefficient. The ranking of the variables was based on the average index and these values can then reflect the discrete categories.

CHAPTER 7

DATA ANALYSIS AND DISCUSSIONS

7.1 INTRODUCTION

The data analysis is organised according to the sequence of the surveys carried out. There are three main surveys as discussed in detail in Chapters 6 and 7.

The aims of the analysis for each of the three surveys are as follows:

a) **Survey I**

To identify all factors and sub-factors affecting safety performance on construction sites from both the Principal Contractors (PC) and Specialist Contractors (SC) point of view.

b) **Survey II**

To establish the indicators that influence the factors and sub-factors identified in Survey I.

c) **Survey III**

To measure the degree of importance for each safety control measure (SCM) for the inclusion in SPMT, identified from both Survey I and Survey II. Survey III also establishes the weighting of each SCM.

The data obtained from these three surveys will establish and validate the important factors affecting SCMs on construction sites. The identified SCMs and indicators chosen will then form the basis for the development of SPMT.

7.2 SURVEY I

A total of 182 questionnaires were sent out to the ECI Safety Task Force to be distributed to both Principal Contractors (PCs) and Specialist Contractors (SCs). 63 questionnaires were returned with 47 PCs and 16 SCs.

7.2.1 Section A – General information

As discussed in Chapter 6, the questionnaires were sent out to the ECI Safety Task Force members, to be distributed to PCs and SCs and the results are discussed below.

Response from PCs

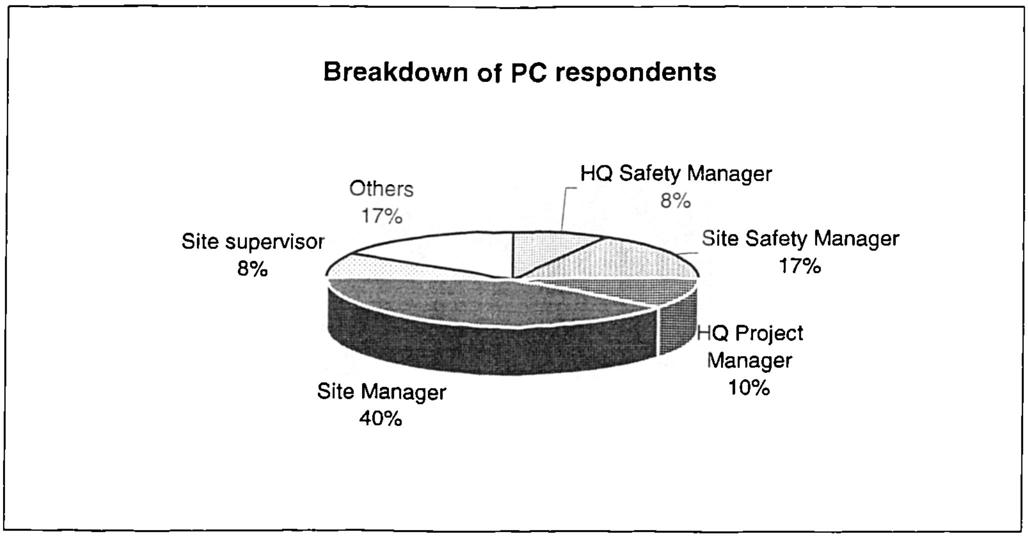


Figure 7.1 Breakdown of the PC respondents – survey results

Figure 7.1 clearly indicates that the majority of the PC respondents were site managers (40%), followed by site safety managers, making up 17% of the response. HQ management constitutes of 10% and site supervisors makes up a further 8%. The group labelled others makes up 17% and comprises a construction engineer, a construction director, a scaffold inspector, a HQ construction manager and an inspection manager. This demonstrates a good spread of expertise within a contracting organisation.

Response from SC

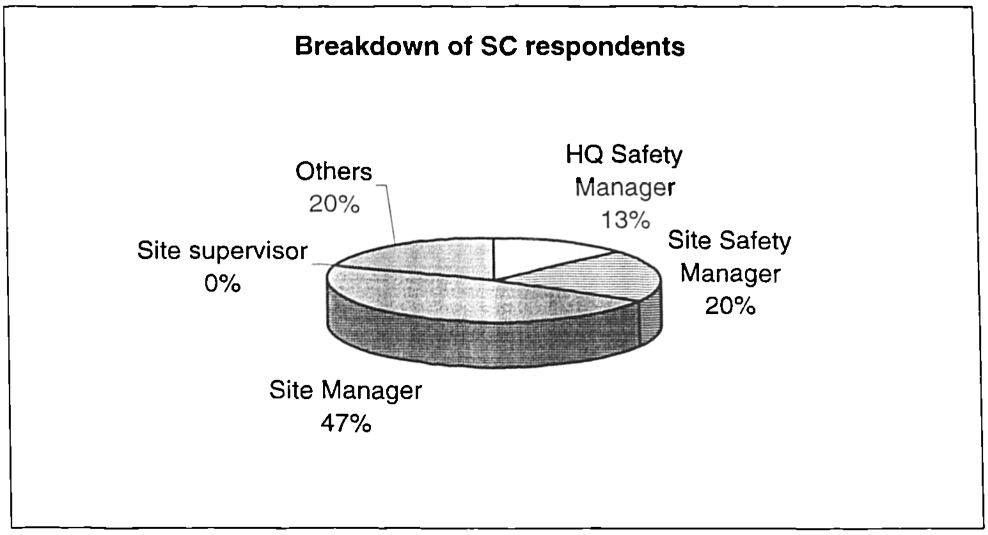


Figure 7.2 – Breakdown of SC respondents – survey results

Figure 7.2 for SC shows that the site managers again provide the greatest response with 47%. Site safety managers and the group labelled 'others' yielded an equal response of 20% where 'others' comprises of a regional director, a construction director and construction managers. HQ safety managers make up the remaining 13% of the group. There was no response from any site supervisors. As with the PC group, the respondents from the SC group are experts within the construction sector implying that both the PC and SC respondent groups have experience of the ongoing safety problems within construction. Their input will help in identifying the critical factors and sub-factors that affect safety performance on site.

Respondents working sector

Figure 7.3 shows the respondents area of work. The majority of the respondents are involved in engineering work with some civil and building work. This was due to the involvement of the ECI Safety Task Force participation in distributing the questionnaires as most ECI members are involved in the engineering sector.

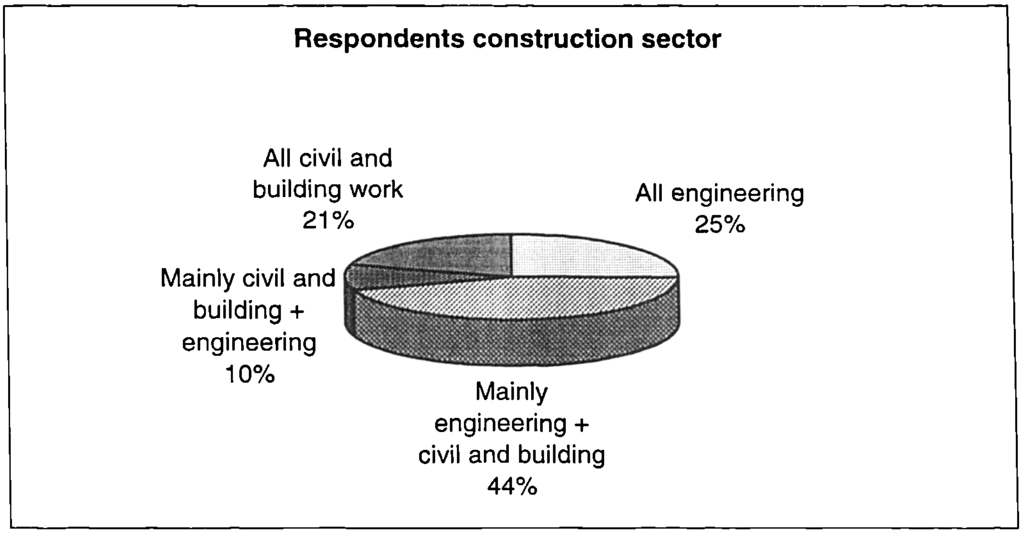


Figure 7.3 – Respondents construction sector – survey results

Experience

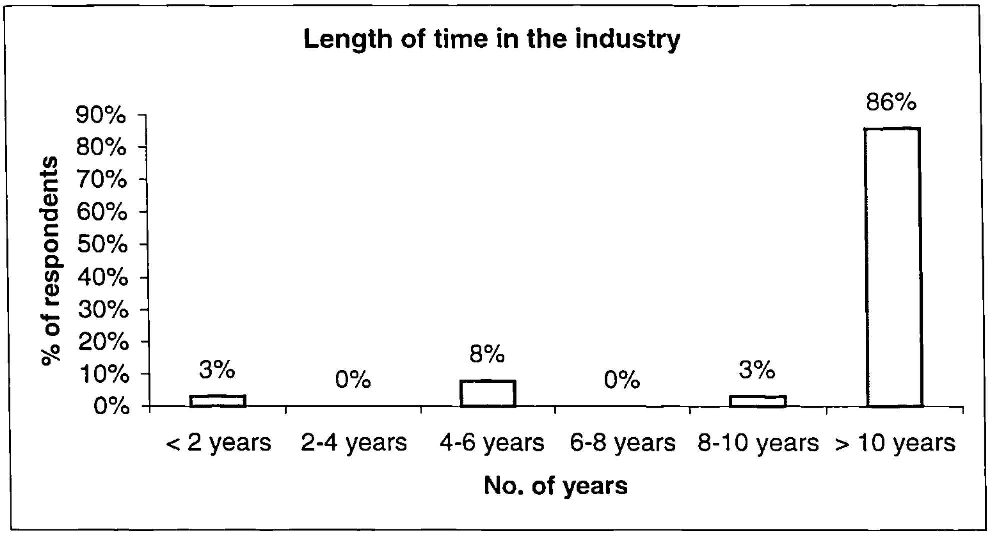


Figure 7.4 – Length of time in construction industry – survey results

Figure 7.4 reveals that the majority of the respondents were very experienced personnel with 86% of the respondents having over 10 years of experience. This is a good figure to highlight the quality of the respondents who are very experienced in their scope of work.

7.2.2 Section B – Analysis of the factors and sub-factors

The objective of this section was to establish the relative importance of the factors and sub-factors contributing to improve safety performance on construction sites. To achieve this objective, a ranking method was used by computing the mean values of the respondents' response as discussed in Chapter 6. The results were classified based on the average index as follows:

Very High Importance	4.50 ≤ mean score ≤ 5.00
High Importance	3.50≤ mean score ≤ 4.50
Slightly Important	2.50 ≤ mean score ≤ 3.50
Average	1.50 ≤ mean score ≤ 2.50
Low importance	0.50 ≤ mean score ≤ 1.50
Very low importance	0.00 ≤ mean score ≤ 0.50

The significance of using a ranking method is that it identifies the 'top' choice, which can then be used to establish the most important factors and sub-factors among several choices. Only variables with a ranking of 'high importance' and 'very high importance' were chosen for SPMT. A statistical test was conducted to reaffirm and support the ranking by both the PC and SC. If a null hypothesis was rejected, it indicated that there was a significant agreement with the ranking, determined at 95% confidence level. This simply meant that there was an agreement in the ranking between both groups of respondents. However where there was no significant agreement, the PC ranking was used to validate and establish the findings of the research because they formed the majority of respondents.

The survey invited respondents to rank the effectiveness of the techniques for improving safety performance on construction sites. The categories were as follows:

5 = Very important

4 = Important

3 = Average

2 = Less important

1 = Not important

Techniques used by Head-office management

Table 7.1 shows the ranking of the techniques used by head-office management. The correlation test conducted on both groups of respondents gives the Spearman's correlation coefficient, rho (R_s) of 0.765 and a significance value of 0.038<0.05. This implies significant agreement in the ranking. The alternative hypothesis H_1 that there is a strong agreement between PC and SC ranking was thus accepted. Both the PC group and the SC group had classified 'procedures for reporting near miss' as 'very high importance' sub-factor influencing techniques used by head-office management.

Table 7.1 - Techniques used by Head-office management – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Carry out safety audit	3.60	3.69	5	4		
Provide up-to-date safety documentation	4.04	4.19	3	2		
Hazard analysis during design and planning stage	3.72	3.59.	4	5	0.765	0.038
Procedures for reporting accidents/incidents	4.30	3.75	2	3		reject H_0
Procedures for reporting near misses	4.51	4.56	1	1		
Short and long term budget	2.60	2.69	6	6		

The results of the above analysis show that the PC's ranking reaffirms the SC's ranking, meaning that the objective of establishing the sub-factors for this factor has been demonstrated.

Techniques used by Site-office management

Table 7.2 shows the sub-factors that are used by site-based management in improving safety performance on sites. The null hypothesis (H_o) is accepted and this shows that there is no strong agreement in the ranking amongst the group of respondents. The Spearman's correlation coefficient, rho (R_S) is 0.55 and has a significance value of 0.98. This value is much higher than 0.05 that would reject the alternative hypothesis, H_1 at a confidence level of 95%. Among the sub-factors identified, 'consistent motivating personnel on site' was ranked highest by both PC and SC group with a mean score of 4.51 and 4.56 respectively. This means that this sub-factor was classified as 'very high importance' towards the techniques used by site-office management to implement safety performance on site.

Table 7.2 - Techniques used by Site-office management – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Providing useful safety document	4.04	4.19	5	2		
Displaying safety policy	3.72	3.56	6	6		
Full time safety representative	4.30	3.75	2	4		
Consistently motivation personnel on site	4.51	4.56	1	1	0.55	0.98 accept H_o
Frequent meetings with supervisors	4.30	3.94	2	3		
Frequent meetings with specialist contractors	4.13	3.75	4	4		
Selection of specialist contractor	4.23	3.69	3	5		

The results of the analysis have established the sub-factors for this factor and their ranking according to the influence towards safety performance within construction. Although the statistical test shows that there is a disagreement in the ranking between both respondent groups, the objective of establishing the sub-factors for this factor has been achieved using the PC's ranking.

Techniques used by supervisors

Table 7.3 shows the calculated value of Spearman's correlation coefficient, where rho (R_s) is 0.205. This indicates that there is no strong agreement between the two groups of respondents. The significance value achieved is 0.370>0.05.

Table 7.3 - Techniques used by supervisors – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Formal inspection and checking	4.23	3.75	2	4		
Informal inspection and checking	4.04	4.13	5	2	-0.205	0.370 accept H_o
Regular toolbox talk	4.17	4.25	3	1		
Incident reviews and reporting	4.11	3.75	4	4		
Pre-task awareness talk	4.45	3.94	1	3		

The PC group claimed that the 'pre-task awareness talk' was ranked highest with a mean score of 4.45. the SC group responded that 'regular toolbox talks' was the major sub-factor influencing the techniques used by supervisors to implement safety performance on site. Overall, for this factor – 'techniques used by supervisors', all the sub-factors were classified as being of 'high importance' based on the average index.

The results of the analysis have established the sub-factors for this factor and their ranking according to the influence towards safety performance in construction. Although the statistical test shows that there is a disagreement in the ranking between both respondent groups, the objective of establishing the sub-factors for this factor has been achieved using the PC's ranking.

Engineering control

As indicated by Table 7.4, both groups very nearly agreed on the ranking of the sub-factors. The value of the Spearman's correlation coefficient, rho (R_s) is 0.886 and a significance value of $0.009<0.05$ was obtained, which indicates a significant agreement in the ranking. Hence, the null hypothesis H_o is rejected. The alternative hypothesis H_1, with a strong significance agreement in the ranking between both groups with 95% confidence level, was achieved.

Table 7.4 – Engineering control analysis – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Carrying out risk analysis and method statement for hazardous tasks	4.76	4.69	1	2		
Full knowledge of installation process	4.26	3.94	4	5		
Full knowledge of maintenance and repairs	3.81	3.63	6	6		
Understanding of work procedural and relevant standards	4.11	4.25	5	4	0.886	0.009 reject H_o
Obtaining permission and permit to work before starting work	4.62	4.81	2	1		
Ensuring all machinery and equipment in good working condition	4.38	4.38	3	3		

The PC group ranked 'carrying out risk analysis and method statement for hazardous tasks' highest whilst SC group viewed 'obtaining permission and permit to work before starting work' as the highest influential sub-factor to the factor engineering control. Both sub-factors were ranked as 'very high importance' based on the average index. The results of the above analysis have established the sub-factors for this group of factors influencing safety performance in construction. The statistical test shows that the PCs ranking reaffirms the SCs ranking and the objective of establishing the sub-factors for this factor has been demonstrated.

Housekeeping

Table 7.5 shows the statistical test for the safety factor 'housekeeping'. This indicates that the null hypothesis H_0 is accepted, proving that there is no significant agreement in the ranking between groups of respondents. The Spearman's correlation coefficient rho (R_s) is 0.70 with a significance value of 0.094. This value is higher than 0.05 which rejected the alternative hypothesis, H_1, at a confidence level of 95%.

Table 7.5 – Housekeeping – survey results.

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Good storage practice	4.21	4.00	4	5		
Proper material handling	4.38	4.13	3	4		
Hazard identification on hazardous material	4.57	4.53	1	1	0.700	0.094 accept H_0
Hazardous material management	4.43	4.27	2	2		
Proper waste management	4.19	4.25	5	3		

Both PC and SC ranked 'hazard identification on hazardous material' as being of 'very high importance' based on the average index. The remaining sub-factors were all classified as being of 'high importance'. The results of the analysis have established the sub-factors for this factor and their ranking according to the influence towards safety performance in construction. Although the statistical test shows that there is a disagreement in the ranking between both respondent groups, the objective of establishing the sub-factors for this factor has been achieved using the PC's ranking.

Training

Table 7.6 shows the statistical test conducted on this factor confirmed that there is no significant agreement in ranking between the two groups of respondents and the null hypothesis H_0 is accepted. The Spearman's correlation coefficient rho (R_s) is 0.657 and has a significance value of 0.078>0.05. The higher percentage rejected the alternative hypothesis at a confidence level of 95%. However, both groups ranked 'induction course for all personnel' highest. Both factors were also classified 'very high importance' based on the average index.

Table 7.6 – Training – survey results

Sub-factors	**PC mean**	**SC mean**	**Ranking by PC**	**Ranking by SC**	**Spearman coeff, rho**	**Notes**
Induction course for all personnel	4.72	4.75	1	1		
Team training	3.72	3.69	6	6		
Technical competence training and assessment	4.11	4.19	4	3	0.657	0.078
Emergency response training	4.23	3.88	2	5		accept H_o
On-going training for specific tasks	4.09	4.06	5	4		
Toolbox talks	4.21	4.44	3	2		

The results of the above analysis have established the sub-factors for the factor 'training'. Although there was no agreement between the two groups of respondents, and the objective of establishing the sub-factor that influence has been achieved using the PC's ranking.

Communication

From Table 7.7, the statistical test indicates that there is a significant agreement in the ranking between both the PC and SC respondents with a confidence level of 95% being achieved. The analysis yields a Spearman's correlation coefficient, rho (R_s) of 0.952 with a significance value of 0.08>0.05. Both the PC and SC groups of respondents ranked 'procedures for reporting accidents/incidents' as the most important sub-factors with a mean score of 4.17 and 4.44 respectively. This sub-factor was also classified as 'high importance' by both respondent groups.

Table 7.7 – Communication – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Procedures for reporting accidents/incidents	4.17	4.44	1	1		
Procedures for reporting near misses	4.15	4.13	2	3		
Procedures for conveying instruction	4.09	4.06	4	4		
Procedure/channel for recommendation and improvements	3.98	3.75	5	5	0.952	0.000 reject H_o
Suggestion scheme	3.51	3.44	7	6		
Poster campaigns, safety booklets	3.68	3.38	6	7		
Proper signage	3.98	3.75	5	5		
Health and Safety Committee	4.11	4.19	3	2		

The results of the above analysis have established the sub-factors for this group of factors influencing safety performance in construction. The statistical test shows that the PCs ranking reaffirms the SCs ranking and the objective of establishing the sub-factors for this factor has been established.

Safety culture

From Table 7.8, the statistical test conducted on the null hypothesis H_o: that there is no significant agreement in the ranking between PC and SC is rejected. The analysis yields a Spearman's correlation coefficient, rho (R_s) of 0.817 with a significance value of 0.007>0.05. There was no surprise to find that there was agreement in the ranking of the sub-factors 'everybody knows safety rules and procedures' and 'employees use PPE where appropriate' as being 'very high importance' by both PC and SC based on the average index. The sub-factors that also achieved a 'very high importance' ranking were 'safe behaviour related to tool/equipment, machinery' and 'employees know where safety equipment is and how to use it' but were ranked by PC only. The remaining sub-factors fall into the category of 'high importance'.

Table 7.8 – Safety culture – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Everybody knows safety rules and procedures	4.68	4.63	1	1		
Workers exhibit safe behaviour	4.45	4.25	4	6		
Safe behaviour related to tool/equipment, machinery	4.45	4.38	4	5		
Employees use PPE where appropriate	4.62	4.56	2	2		
Safe working environment exist	4.49	4.38	3	4	0.817	0.007 reject H_o
Employees know where safety equipment is and how to use it	4.45	4.50	4	3		
Employees make time to be safe	4.45	4.50	4	3		
Operatives involved in safety audit	4.21	3.88	5	7		

The results of the above analysis have established the sub-factors for this group of factors influencing safety performance in construction. The statistical test shows that the PC's ranking reaffirms the SC's ranking and the objective of establishing the sub-factors for this factor has been demonstrated.

Health

From Table 7.9, it can be seen that both the PC and SC agree on the ranking of the sub-factors. The Spearman's correlation coefficient, rho (R_s) was 0.886 with a significance value of 0.9% which is less than 5%. This coefficient value indicates a significant agreement in the ranking between both groups at a confidence level of 95%. Thus the alternative hypothesis H_1 was accepted and the null hypothesis H_o is rejected.

Table 7.9 – Health – survey results

Sub-factors	PC mean	SC mean	Ranking by PC	Ranking by SC	Spearman coeff, rho	Notes
Physical stress check-up	3.47	2.88	5	6		
Emotional stress check-up	3.39	2.81	6	5		
Pre-employment medical	3.94	3.38	3	4		0.009
Regular health surveillance	3.70	3.50	4	3	0.886	reject H_o
Health risks management	4.13	3.75	2	2		
Medical facilities	4.57	4.50	1	1		

Both the respondents groups ranked 'medical facilities' and 'health risks management' highest among the sub-factors within the health factor. The results of the above analysis have established the sub-factors for this group of factors influencing safety performance within construction. The statistical test shows that the PCs ranking reaffirm the SCs ranking and the objective of establishing the sub-factors for this factor has been demonstrated.

The results from Survey I were used to develop the indicators for each of the safety factors. These identified indicators were then validated with the aid of a group of safety experts. The following section discusses the results from the expert opinion phase (Survey II).

7.3 SURVEY II

Survey II was based upon expert opinion, an approach which is explained in detail and justified in Chapter 6. Its objective was to establish all of the important indicators for SPMT. A total of 10 experts from the ECI Safety Task Force participated in identifying the indicators for all the SCMs.

7.3.1 Changes of the structure of SCM

Figure7.5a and Figure 7.5b show the changes that the SCMs have undergone according to Survey I and Survey II. Changes were implemented based upon the level of importance and the suggestions made through both surveys with the main alterations being to the name given to all of the variables affecting safety performance. Instead of using factor and sub-factors it was suggested that the term safety control measure (SCM) would be better used, automatically explaining its purposes. This was agreed and for this reason, the term SCM was adopted.

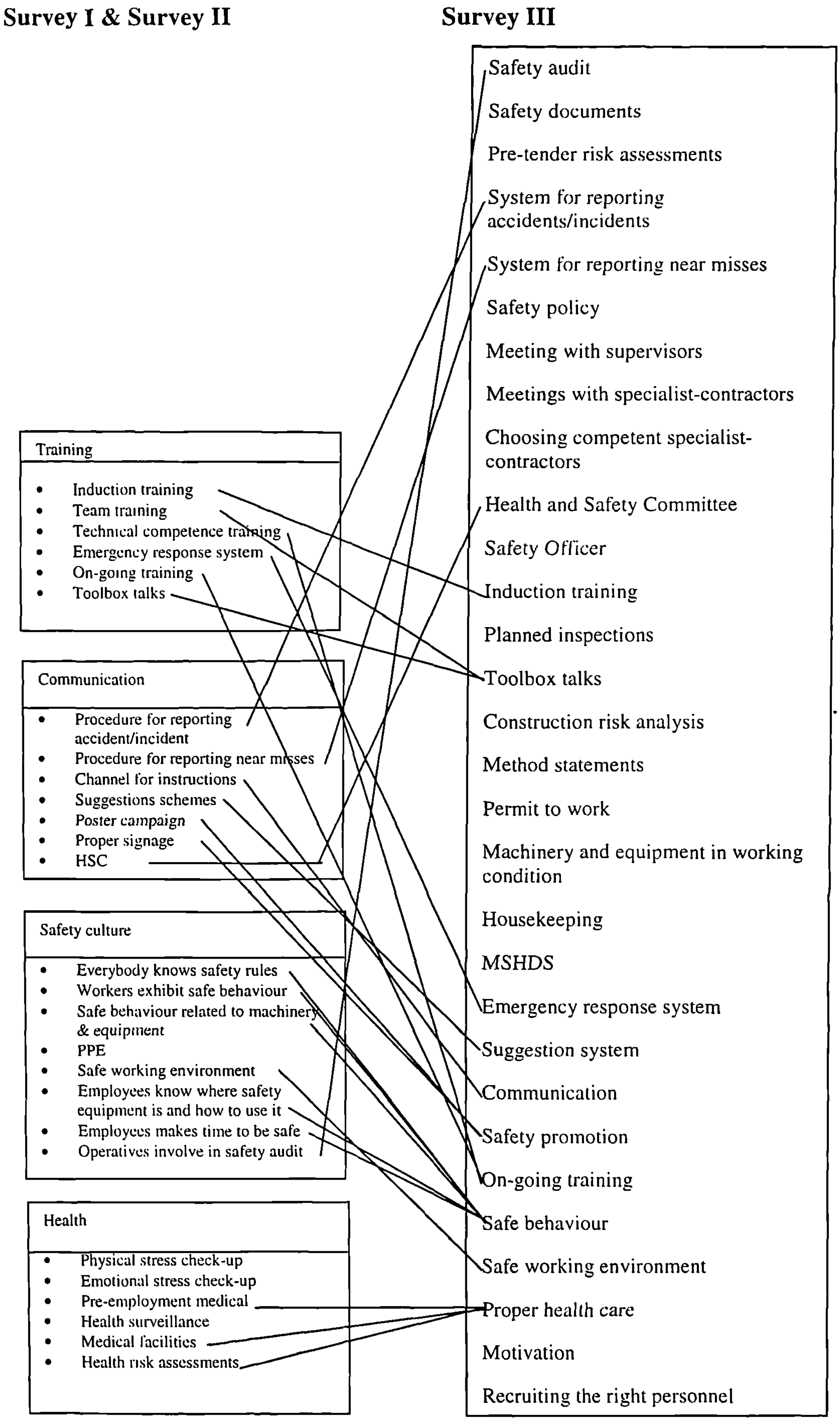
It can be seen from Figure 7.5 that the changes comprise either a combination or. deletion of variables. The combinations were formed based upon suggestions made by the 'experts'. The following summary describes the changes made to the SCMs:

a) Techniques used by HQ:
   - deletion made to the sub-factor 'short and long term budget' due to its low ranking score.

b) Techniques used by supervisors:
   - combination of sub-factors 'formal and informal checking' and 'formal and informal inspection' under the SCM of 'planned inspections';
   - 'toolbox talk' and 'pre-awareness talk' were combined under the SCM of 'toolbox talk'; and
   - 'incident review and reporting' were put under the SCM of 'meeting with supervisors' where it is a formal procedure.

Figure 7.5a – Changes to SCM – survey results

Figure 7.5b – Changes to SCM – survey results



c) Techniques used by site management:

- all sub-factors were maintained under the same name.

d) Engineering control:

- 'knowledge of installation process', 'knowledge of maintenance' and 'understand work procedure and standards' were combined under the SCM 'recruiting the right people'. This combination was put under a new title to give a more comprehensive meaning to it.

e) Housekeeping:

- 'storage practice', 'material handling', 'hazardous material management' and 'proper waste management' were combined under the SCM 'housekeeping'; and
- 'hazard identification' was pun under the SCM of 'construction risk analysis'.

f) Training:

- all the sub-factors training listed were suitable for the SCM of 'on-going training';
- 'induction training' was listed under the SCM 'induction training';
- 'toolbox talk' and 'team training' were categorised under the SCM 'toolbox talks'; and
- 'emergency response system' was under the SCM 'emergency response system'.

g) Communication:

- 'poster campaign' and 'proper signage' were combined under the SCM 'safety promotion'.

h) Safety culture:

- Six sub-factors were categorised under the SCM 'safe behaviour' and they were 'everybody knows safety rules', 'workers exhibit safe behaviour'; 'safe behaviour related to machinery and equipment' 'PPE', 'employee know where safety equipment is and know how to use it' and 'employees makes time to be safe';
- 'safe working environment' is categorised under the same name; and
- 'operatives involved in safe audit is categorised under the SCM 'safety audit'.

i) Health:

- sub-factors 'physical stress check-up' and 'emotional stress check-up' were deleted due to their low mean score; and
- the other four sub-factors were combined together under the SCM of 'proper health care'.

7.3.2 Discussions of Results for Each SCM and Indicators by the Experts

The following section describes in detail the analysis based on the experts' opinion for each SCM with the indicators. All 30 SCMs are identified and discussed.

SCM - Safety audit

Indicators	Mean
Frequency of safety audit	4.6
Involvement of all level of personnel	4.5
Receive pre-audit training	4.2
Carry out safety audit analysis	4.7
Develop action plan on audit analysis	4.7
Feedback to site any results	4.5

The indicators for the SCM - safety audit were suggested as above. All the indicators were classified as being of 'very high importance' based on the average index ratings. The frequency of carrying out the safety audit was suggested to be at least once during the project (instead of annually) as a minimum requirement. The participation of personnel should not be restricted to HQ staff only but involve all staff. For the indicator 'safety audit analysis', it was agreed that it should be followed by an action plan based on the results and also a review of the action plan. All results from the analysis should be fed back to the relevant parties. The factors above were further developed for their inclusion in SPMT.

SCM - Up-to-date safety documents

Indicators	Mean
All relevant safety documents exist on sites	4.7
Review and change when necessary and required	4.7
Inform all relevant personnel on any changes	4.2

This SCM received a very high mean score, with values ranging from 4.1 to 4.75, meaning that all of the indicators are in the categories of 'high importance' and 'very high importance'. All of the indicators suggested to the experts were accepted. There was a suggestion to list out the safety documents in question, however this would be problematic due to sheer numbers. It was therefore decided that examples would be given when designing the questionnaires relating to SCM – safety documents.

SCM – Pre-tender risk assessment

Indicators	Mean
Carry out pre-tender risk assessment	4.6
Compliance with the legislation	3.9
Examine workplace design and layout for health and safety factors	4.3
Communicate finding in health and safety plan	4.3

The SCM – pre-tender risk assessment indicators were not viewed as something new to the experts. Indeed it was stipulated in legislation such as the CDM Regulations 1994 as being necessary to carry out such tasks. The mean scores achieved for these indicators were all high ranging from 3.9 to 4.6 - classifying it as 'high importance' to 'very high importance'.

SCM – System for reporting accidents/incidents

Indicators	Mean
System for reporting accidents/incidents exists on site	4.5
Inform all personnel about the system	4.0
Provide competent and trained staff to undertake reporting	4.3
Record all reporting	4.1
Carry out investigations and analysis	4.3
Feedback all investigation analysis to all personnel	3.9

This is an important indicator. A good suggestion was to include the type of accidents and reporting beyond what is required by the legislation. They are:

- fatality
- major accidents/incidents
- lost days
- doctor's cases
- damage to property
- environmental damage

For SPMT, it was decided that all accidents/incidents must be investigated regardless of their scale. This is the only way to learn about the cause of an accident or to identify repetitive occurrence and its cause. All accident/incident analysis should be fed back to the workforce.

SCM – System for reporting near misses

Indicators	Mean
System for reporting accidents/incidents exists on site	4.1
Inform all personnel about the system	3.9
Provide competent and trained staff to undertake reporting	3.6
Record all reporting	3.9
Carry out investigations and analysis	3.2
Feedback all investigation analysis to all personnel	3.8

The system for reporting a near miss must be made known to all personnel receives the highest mean score of 4.1, classified as 'high importance'. The lowest mean score was for the indicator 'all near miss incidents should be reported during meetings and must be recorded as minutes'. Reporting near misses is still seen as difficult to implement by employers which explains why the lower score was achieved for this SCM.

SCM - Safety policy

Indicators	Mean
Safety policy must convey company policy, objectives and expectation of personnel with regard to safety	4.8
Should be in one page (A4 or A3).	3.8
Must be displayed	4.1
Review regularly	4.0

The safety policy SCM is another factor that must comply with legislation. It was agreed that the safety policy must clearly demonstrate the management's commitment towards safety.

SCM – Meeting with supervisors

Indicators	Mean
Frequency of meetings with supervisors	4.4
Record attendance	4.1
Discuss any substandard work/incidents	4.0
Define follow-up actions	4.5

All experts agreed that the minimum frequency for the meetings should be once a week. This indicator achieved a mean score of 4.4, classified as being of 'high importance'. The most important comment made was for the 'define follow-up actions'. The suggestion made for this indicator was that it should define: a) who should carry out the remedial work; b) how to carry out the work; and c) when to do it. This approach will ensure that the responsibilities are passed on to the respective persons.

SCM – Meeting with specialist-contractors

Indicators	Mean
Frequency of meetings with specialist-contractors	4.4
Record attendance	4.1
Discuss work progress, health and safety matters	4.3
Review remedial actions undertaken by specialist-contractors	4.1

All the indicators achieved a high mean score of 4.1 and above. The suggested frequency for meetings with sub-contractors is weekly, with a mean score agreement of 4.4, meaning that it is classified as being of 'high importance'. Here, it is important to ensure that all remedial actions undertaken by sub-contractors meet the standards specified by contractors.

SCM – Choosing competent specialist-contractors

Indicators	Mean
Company must communicate health and safety expectation to prospective specialist-contractors	4.8
Sub-contractors must demonstrate their previous safety performance record	4.9

This SCM achieved a high mean score of 4.8 and 4.9 classifying it under the 'high importance' category. The importance placed on this indicator clearly emphasises the need for the company to spell out the health and safety objectives and their expectations of the specialist-contractors. An ability pre-qualification questionnaire will help the company to choose specialist-contractors who are reliable and have high safety performance achievements.

SCM – Health and Safety Committee (HSC)

Indicators	Mean
Participation from all levels of personnel	4.2
Responsible for the general oversight of the company safety performance	4.2

This SCM also acquired a high mean score. The experts agreed that it was important to ensure that members of the HSC come from all levels of personnel on site, although keeping the number at a sensible level. The HSC will have a big responsibility with regard to the overall health and safety policies of the company e.g. involvement and reviewing safety performance and reviewing company's procedures and implementation.

SCM – Full time safety officer (SO)

Indicators	Mean
At least 75% of time on project site	3.9
So must be trained and competent	4.4
Responsible for the health and safety matters	4.0
Review company safety performance	4.3

The indicator concerning the amount of time spent on site proved too difficult to achieve an agreement. Some misinterpreted the questions, suggesting that it depends on the site while others suggested that asking the SO to spend 75% of his/her time on site is too much because of the amount of paperwork involved. Some of the experts misunderstood the question thinking 75% on site meant spending it literally on the site, out from the office. What is actually meant here is that the SO is available for the project at least 75% of the time. It was therefore decided that every site should have a safety officer who spends at least 75% of the time on the project. The safety officer is responsible for training, advice and inspections on site.

SCM – Induction training

Indicators	Mean
Induction for all on site	5.0
Training content to be comprehensive	4.6
Conducting the induction	4.2
Evaluation of the induction training	4.0

Induction training SCM is a very important safety factor confirmed by the high rating given by all 10 experts. All the indicators obtained a mean score of 4.0 and above classified as being of 'high importance' and 'very high importance'. The highest value attained was a perfect score of 5.0 for the indicators 'all personnel to have induction'. There were comments on the indicator 'evaluation of the induction training' that too much repetitive training is counter productive. A good suggestion taking into account that the evaluation can be part of a supervisor inspection checklist'.

SCM – Planned inspections

Indicators	Mean
Frequency of inspections	3.8
Supervisors competent and trained	3.9
Plan what to inspect	4.2
Take actions on all substandard situations	4.2
Define follow-up	4.2

All of the experts agreed that inspections should be a daily task. Regarding the indicator 'plan what to inspect', there was a suggestion that inspection should be spontaneous and not planned. This suggestion was ignored because all other experts agreed that there should be a system in place for carrying out inspection for accountability purposes. This indicator obtained a mean score of 4.2 meaning that it is 'highly important'. Action plans should define the who, what and when concept.

SCM – Toolbox talks

Indicators	Mean
Carried out by competent and trained personnel	3.4
Types of talks and frequency of talks	3.5
Record all talks	4.0

The first indicator 'personnel conducting toolbox talks must be competent and trained' received a mean score of 3.4, classifying it as being 'slightly important'. This may be due to the fact that the experts feel that any experienced team leaders or supervisors can handle the toolbox talks without training. However in order to ensure that the right information is conveyed, training must be accepted as a requirement in this system. There was a very good suggestion of defining the talks as two types - the daily pre-task talks and the weekly for general safety.

SCM – Construction risk analysis

Indicators	Mean
Communicate health and safety plan to workers	4.7
Carry out safety briefing before work commences	4.6
Review risk analysis of the task with workers	4.1
Use the analysis for future orientation and training programme	4.2

All the indicators for this SCM obtained a 'high importance' to 'very high importance' mean score. It is important to convey the health and safety plan to respective workers in order to identify the risks involved with the task. A good suggestion by the experts was to include 'safety briefing before work commences'. This was accepted because it ensures that everyone doing the job understands how to carry out the work safely.

SCM - Method statements

Indicators	Mean
Management to identify critical areas with high risk	4.6
Identify responsible individuals involved	4.2
Method statement should be detailed	4.2
Plan for contingencies	4.3

The indicator 'method statement should be available for high risk jobs' acquired a mean score of 4.6 categorising it as being of 'very high importance'. It is also important to identify individuals responsible for the high-risk jobs. The rest of the indicators were ranked as 'high importance' factors.

SCM – Permit to work

Indicators	Mean
Design risk assessment to identify risks	3.3
Identify types of permits	3.5
Issue of permits	4.1
Incorporate method statements	3.5

There was a problem in understanding the question put forward to the experts concerning the need for a permit to work system. A suggestion of rewording the statement was incorporated and accepted as 'design risk assessments to identify risk'. By doing so, the types of permit required would also be identified. The most important indicator, which received a 'high importance' was the 'issue of permits'. The issuer should be responsible for the permits being issued; signed after completion of work; and also for any cancellation or alteration.

SCM - Machinery and equipment in working condition

Indicators	Mean
Only trained and skilled operators to handle equipment	4.6
Machinery manual in place for the operator and maintenance	3.2

The indicator 'employee booklet – general guidelines and instructions for all' was suggested to be included in the second indicator regarding the machinery manual.

SCM – Housekeeping

Indicators	Mean
Good storage areas	3.6
Housekeeping checks	3.9

The factor housekeeping was suggested to be changed to SCM – housekeeping. The sub-factor 'waste management' involves construction waste, recycling and proper waste handling. 70% of the experts agreed this is not important to be included into SPMT.

SCM - MSHDS

Indicators	Mean
MSHDS must be communicated to all relevant personnel	3.6
All related personnel must receive proper training related to use of material	4.2
Review and update MSHDS	4.1

The experts agreed that it was important to communicate the MSHDS to respective personnel before carrying out any work related to the material concerned. Training also had to be provided in the handling and safe use of the material. This indicator obtained a mean score of 4.2. MSHDS must be reviewed and updated immediately on all copies available. There was a good suggestion that the HQ management should keep the master copy of MSHDS for reference.

SCM – Emergency response system

Indicators	Mean
Inform all personnel of emergency operating system	5.0
Provide training for hazardous material	4.7
Carry out drill to stimulate real life situations	4.5

It was unanimously agreed on the importance of the indicator 'to inform all personnel the necessary action to take during an emergency'. This indicator achieved a perfect score of 5.0. There was also a strong agreement on the importance 'to provide training for emergency involving hazardous substances'. For the last indicator 'carry out drills', it was suggested that at least one drill should be carried out per site.

SCM – Suggestions system

Indicators	Mean
Formal and informal suggestion systems exist	4.4
Inform all personnel of suggestion system	4.0
Reward scheme for all accepted suggestion	4.1
Communicate accepted suggestion	3.7

Another way to encourage employee participation is through a formal and informal suggestions system. The experts ranked both formal and informal systems of suggestions as 'very important'. This indicator will encourage employees to give ideas and recommendations. Management must communicate all accepted suggestions through either rewarding, announcing it or commendation in writing, thereby encouraging others to participate.

SCM – Communication

Indicators	Mean
Clear chain of command throughout the project	4.1
Use proper channel to communicate all instructions	3.8
Communication can be both verbal and non-verbal	4.4

Communication factor was changed to communication SCM meaning conveying instructions. There must be a clear chain of command among all personnel throughout the project. This indicator was ranked as 'highly important' with a mean score of 4.1.

A suggestion was accepted which clarifies that communication can be both verbal and non-verbal. This is good as it indicates that communication can be in any form.

SCM – Safety promotion

Indicators	Mean
Communicate safety message through posters and boards	3.6
Signs and guarding to follow standard colour codes	3.9
Posters and boards must be seen by employees at least once a day	3.6
There must a safety poster at entrance	3.6
Change safety posters at least once a fortnight	3.5

The experts suggested that the sub-factors 'safety poster' and 'safety signage' should be combined. Safety signs must follow standard coding and colours. All the indicators were classified as 'highly important'.

SCM – On-going training

Indicators	Mean
Management to provide on-going training or refresher course for relevant personnel.	4.1

It was suggested that the aim of this SCM is to ensure that management do provide continuous training for all employees that are on site.

SCM – Safe behaviour exists on site

Indicators	Mean
Continuous message of safety is exhibited at all times	4.5
Safe behaviour related to work	4.2
Safe behaviour related to tools, equipment and machinery	4.2

This SCM too had been changed and combined where necessary. It was suggested that 'safe behaviour related to work', 'safe behaviour related to machinery, tool and equipment', 'PPE', 'everybody knows where safety equipment is and how to use it' and everybody makes time to be safe' should be categorised under the safe behaviour SCM. The sub-factor 'PPE' was also incorporated into this SCM. This was a good suggestion, ensuring that the SCMs are precise and not too lengthy. The management must convey the message that safety is a main priority along with the other aims of the project.

SCM – Safe working environment exists

Indicators	Mean
Safe working environment is provided for all personnel on site	4.7

This SCM was clear to all and agreed upon with a 'very high importance' rating. The management must ensure that a safe working environment exists for all personnel on site at all times.

SCM – Proper health care

Indicators	Mean
Everyone is entitle to proper health care	4.4
Formal procedure to monitor industrial hygiene	4.2
Pre-employment health assessment	3.0
Qualified first-aid personnel on site	4.4

As with the health factor, all the sub-factors are combined under one SCM – health. This was a good suggestion in order to avoid repetition and being too lengthy with regard to the safety factors to be measured. The sub-factors 'health assessment' and 'medical facilities' were combined under this SCM.

SCM – Motivation

Indicators	Mean
Management sets attainable goals	4.6
Encourage active personnel participation	3.8
Recognise good safety performance	4.1
Implement appraisal system	4.0

The SCM – motivation was also ranked in the categories 'highly important' and 'very high importance'. The role of management to set attainable goals was agreed as being of 'very high importance' with a mean score of 4.6. It was also agreed that personnel must be motivated so as to ensure that the goals are attainable. The experts suggested that recognising good safety performance through an appraisal system does not necessarily mean monetary gain, but more of recognition and appreciation.

SCM – Recruiting the right person

Indicators	Mean
All personnel must have the right and knowledge to undertake the given tasks	4.6
Reference from previous employer	3.3
Probation test	3.4

It was agreed, with a mean score of 4.6 (categorised as 'very high importance') that all personnel must have adequate knowledge in order to undertake their respective tasks. The reference from previous employers and questionnaires filled in by applicants will help to determine his/her ability. It is wise to put any new employees under a probationary period in order to test their ability and knowledge about the work.

Survey II analysis has helped to develop all of the SCMs and respective indicators for SPMT. All the indicators were chosen based on the ratings and suggestions made by the experts. It was decided to further validate the importance of the chosen SCMs and indicators on a bigger sample. Survey III was set out to measure the degree of truth that each indicator is important to each SCM, using the fuzzy linguistic quantifier adopted by Zadeh.

7.4 SURVEY III

7.4.1 Section 1 – General Information

Survey III was carried out in order to measure the degree of importance for both SCMs and indicators over a bigger sample. This sample was discussed in detail in Chapter 6. Two groups of samples were chosen for this exercise – 61 companies from the top UK contractors and 90 companies from the top mainland European contractors for 1998. The response from the UK contractors was very good with a 51% return (out of 61 companies) compared with just 12% (out of 90 companies) from the mainland European group. The majority of the respondents are involved in the civil engineering sector comprising 36% of the response. Figure 7.6 presents the main working sectors of the respondents. This shows that the survey sample gives a good representation at the various construction sectors except for housing.

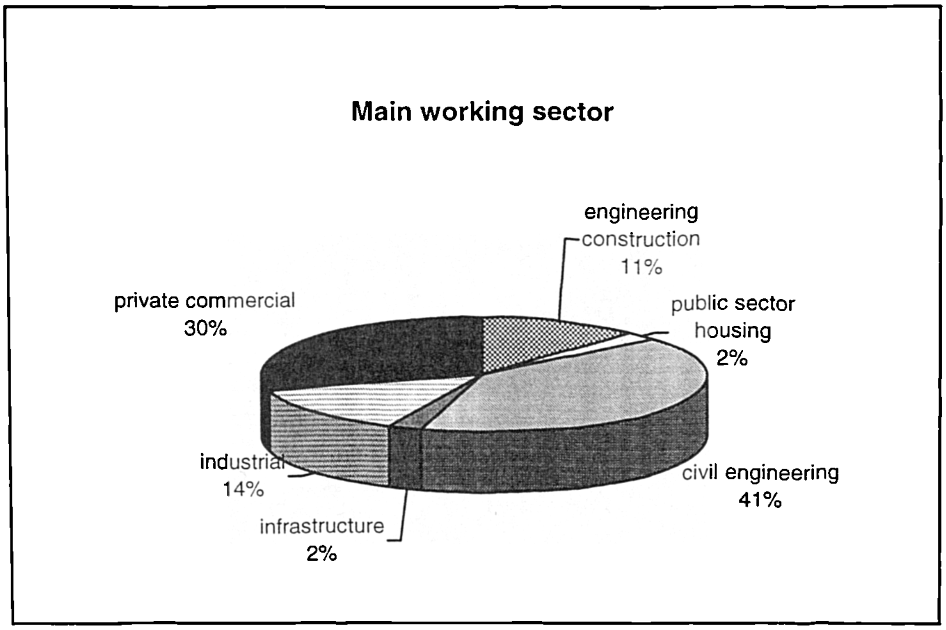


Figure 7.6 – Main working sector – survey results

7.4.2 Section 2 – Carry Out Safety Performance Self Assessment

The aim of this section was to form an understanding of the current situation regarding safety performance assessment. It is important to find out what form of safety performance measurement is being practised on sites, what methods are being used, how long each assessment is and who is involved. The information gathered will contribute to the development of SPMT.

The analysis performed revealed that 86% carry out some form of safety performance assessment compared with just 14% who do not. This is indicative of a positive attitude towards safety. From the group that does assess out safety performance, all adopted both the reactive and proactive methods of assessment. Table 7.10 describes the safety measurement systems used.

Table 7.10– Safety measurement systems – survey results

Safety measurement system	Frequency (%)
Develop an in-house system	86
Customise a standard system	11
Use a system developed externally	3

From Table 7.10, it is clear that many organisations have developed their own in-house measurement system. This strong point emphasises the lack of a standard proactive measurement system. The majority of the approaches adopted have gone through at least some changes in the last five years. Only 3% did not do any reviewing of the measurement system. Among the changes that have taken place are

- increased number of measurements;
- more proactive measurements;
- more reporting of near misses;
- refocus to bring safety within core activities rather than a stand-alone issue;
- make audit and inspections more proactive;
- improve measurement criteria;
- increase publicity about the measurement;
- analysis of causes of accidents;

- greater use of risk assessments;
- continuous improvement;
- change from employing part time safety adviser to full time safety adviser;
- increase measurement and goal setting;
- increase training of staff;
- using surveillance;
- regular safety briefing talks;
- create a central unit for safety;
- increase the involvement of sub-contractors;
- more safety checks on site; and
- increase human resources involvement in safety.

At least 13% of the respondents found it difficult to quantify the time spent on each assessment - ranging from half an hour to 80 hours with most taking 8 hours (one person-day) (Table 7.11).

Table 7.11 – Length of time spent on each assessment – survey results

Time (hour)	Percentage
Cannot quantify	13
0.5	3
1	3
2	8
4	18
6	5
8	37
16	10
80	3

The next question was asked to find out the frequency of the safety performance measurement. The frequencies ranging from one year to less than once a week (Table 7.12). At least 41% of the organisations carry out safety assessment once a month.

Table 7.12 – Frequencies of safety performance assessment – survey results

Range of time	Percentage
Less than once a week	6
Once a week	9
2-3 weeks	12
Every month	41
Every 3 months	14
Every 6 months	12
Every year	6

The respondents were also asked how much human resource is allocated to each assessment (Table 7.13). Overall there was involvement from all categories of respondents for most companies. From Table 7.13, it can be concluded that the trend for time allocation is up to 8 hours per assessment or one person-day. There are still companies that spend more than 18 hours for the same assessment. The table also provides a clear indication of a high distinct lack of involvement from all levels of the workforce except for the site management and safety management. This clearly reflects a true picture of what is actually going on in the industry. It is commonly thought that safety is the job of the safety officer and site management alone and that others on site do not have to play an active role in it. For this reason there is a larger percentage of involvement on the part of both groups. Others here were from HQ internal auditors and senior managers.

Table 7.13 – Time allocation for human resource involvement in assessment– survey results

Range of time (hr=hour)	Hr1 (%)	Hr2 (%)	Hr3 (%)	Hr4 (%)	Hr5 (%)	Hr6 (%)	Hr7 (%)
No involvement	73.0	38.9	69.5	54.1	86.1	40.6	91.6
0<hr<2	2.7	19.4	8.3	10.8	8.3	5.4	5.6
2<hr<4	2.7	11.1		13.5	5.6	8.1	2.8
4<hr<6	8.1	2.8	2.8	5.4		5.4	
6<hr<8	8.1	25.0	11.1	13.5		5.4	
8<hr<10						27.0	
10<hr<12							
12<hr<14							
14<hr<16			8.3			2.7	
16<hr<18							
> than 18	5.4	2.8		2.7		5.4	

Hr1 external examiner
Hr2 site management
Hr3 corporate management
Hr4 site supervisors
Hr5 operatives
Hr6 safety management
Hr7 others

The next question aimed to establish what methods were adopted for safety performance measurement (Figure 7.7). The highest responses were checklists, observations and document checks. Only 15% used interview methods and 10% used questionnaires.

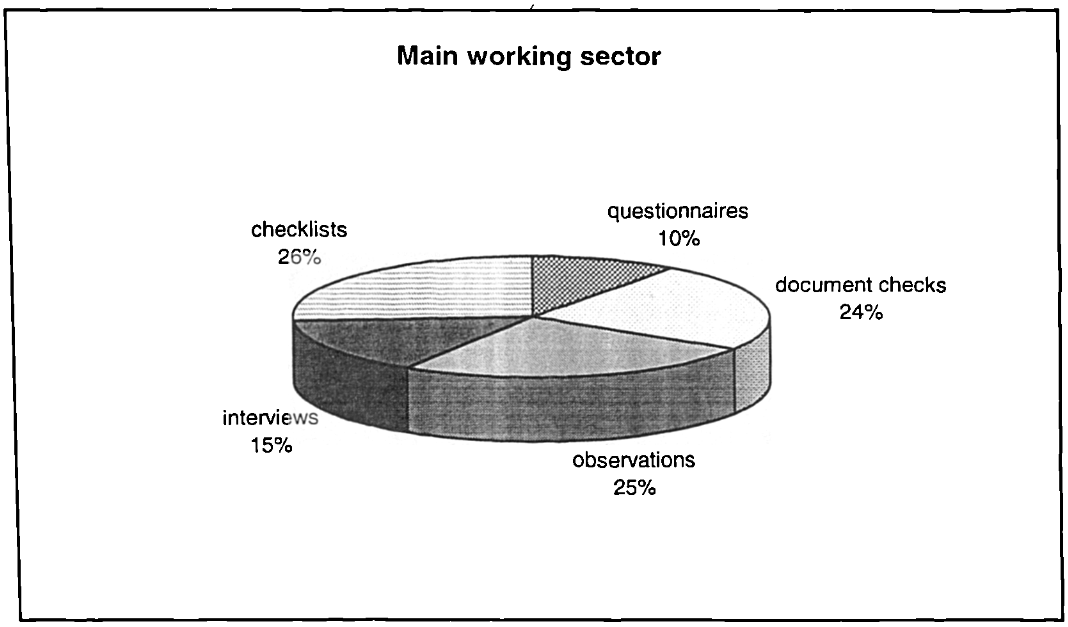


Figure 7.7 – Methods adopted for carrying safety performance assessment – survey results

Following an assessment, just 40% of the respondents communicated the results to personnel on site. This clearly shows that management still considers safety as their responsibility alone, with others on site not having to know anything about it. Table 7.14 describes what types of actions were taken following an assessment. It can be seen that the majority of the respondents take action after an assessment, record the actions and review where necessary.

Table 7.14 – Types of action plan following an assessments – survey results

Types of actions	Percentage
No actions taken	0
Actions resulting from assessment are rare and usually minor	5
Actions are agreed, recorded and reviewed	87
Actions are taken at the time but no record is kept	3
Actions are taken after the assessment but no record is kept	5

This analysis has helped form a better understanding of the current construction industry safety performance assessments. The information gathered also contributed to the development of SPMT.

7.4.3 Section 3 –Ranking of safety control measures

The aim of this section is to determine the ranking of each of the SCMs. The SCMs are grouped into three categories - hardware (engineering system and control), software (management, work system and procedures) and people (behaviour). Due to the small size sample from the mainland European respondents, it was difficult to make any concrete conclusions. Nevertheless, the following discussions were carried out to observe the ranking trend based on the mean between both groups in comparison with the overall mean.

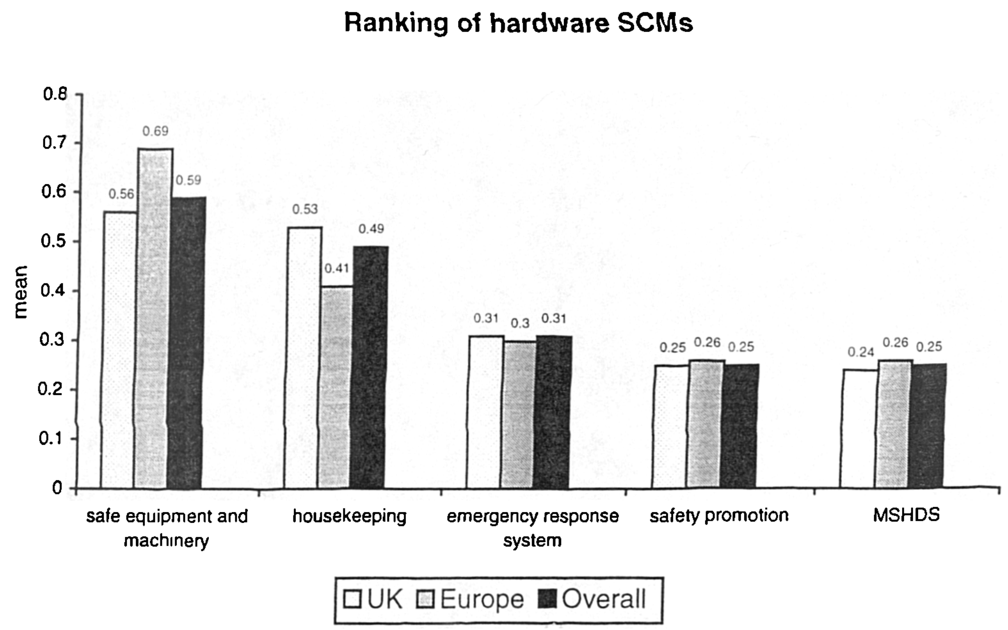


Figure 7.8 – Ranking of hardware SCMs – survey results

Figure 7.8 shows the ranking trend between both groups. The SCM safe equipment and machinery was ranked highest by both respondents group. The lowest SCM ranked by UK group was MSHDS while the European group ranked safety promotion and MSHDS as the lowest. The overall means agree with the ranking of both respondent groups.

The next ranking group was the 'software' group for which, as can be seen from Figure 7.9, there were 20 SCMs included. Overall, both respondent groups ranked the construction risk analysis and training SCMs highest. The overall mean confirms this ranking too. However the following ranking differ between both respondent groups. The UK group ranked method statement SCM as third while the European group ranked the safety meeting with supervisors SCM as its third ranking. The European group ranked method statement SCM as the fifth ranking.

There was difference with the lowest ranking either. The UK group ranked proper health care and Health and Safety Committee SCMs as the lowest while European group ranked procedures for reporting near misses and safety documents SCMs as the lowest. The overall ranking had all the four SCMs ranked lowest by both respondent groups as the lowest.

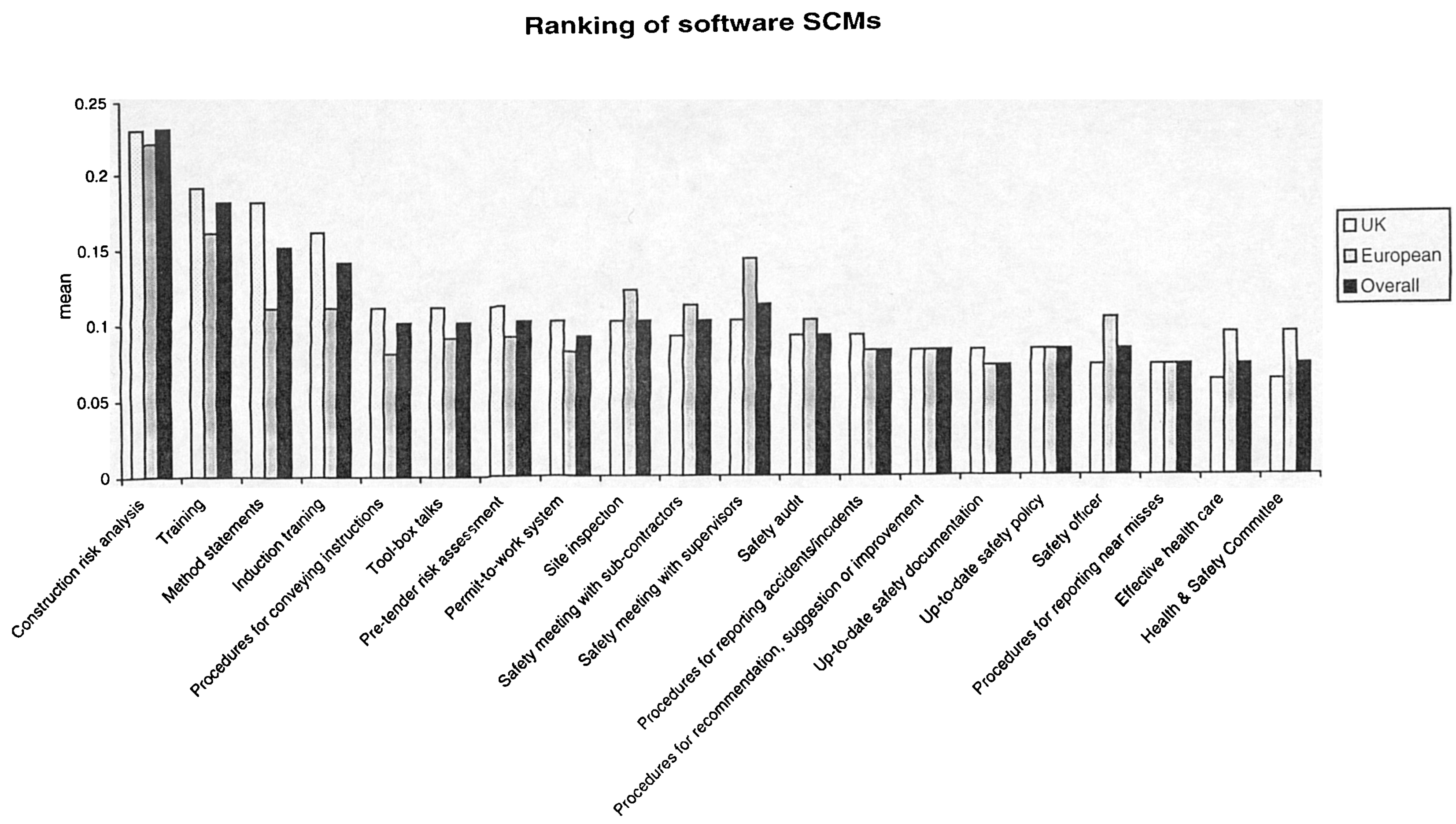


Figure 7.9 – Ranking of software SCMs – survey results

For the 'people' group, there was almost similar trend in the ranking between both teams. The UK group had ranked 'safe working environment' as the most important compared with fourth by the European group which considered the groups the most important SCM to be 'motivation' followed by 'safe behaviour'. The second most important SCM for the UK group was the 'right person for the right job'. The European group gave this SCM a third ranking. Both groups agreed on the last ranking as being 'selection of specialist-contractors based on safety issues'.

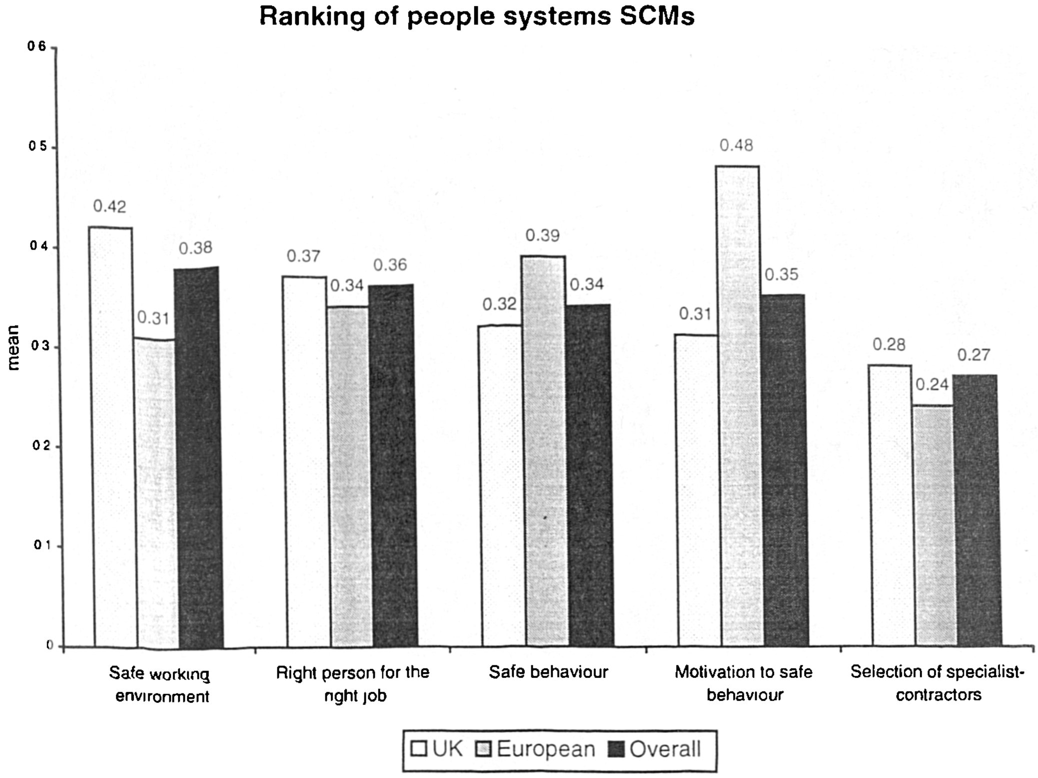


Figure 7.10 – Ranking of people system SCMs – survey results

The above analysis compares the ranking between both respondents groups. From the discussion there exist some differences in ranking trend especially in the 'software' group, but no conclusions can be drawn from this differences due to the small sample from the European group.

7.4.4 Measuring the truth of 'IMPORTANCE'

This section aims to measure the truth concerning the degree of importance placed on each SCM and the indicators. The analysis will also identify the weights for each SCM, achieved by adopting the fuzzy majority approach as explained in Section 6.2. To obtain the answers, the following steps were adopted:

1. identifying intrinsic properties;
2. determine the linguistic variables;
3. determining the domain of the fuzzy variables;
4. calculating the truth of linguistic quantified statements; and
5. calculation of the fuzzy logic based calculus of linguistically quantified propositions.

Identifying intrinsic properties

A fuzzy set has several intrinsic properties that affect the way the set is used and how it participates within a model. To develop the linguistic quantifier, the following were assumed:

Q = ' most'

Y = (indicators)

F = (important)

Determine the linguistic variable

The fuzzy modelling technique revolves around the idea of a linguistic variable. At its root, a linguistic variable is the name of a fuzzy set. The linguistic variable used for this exercise is **IMPORTANCE**. The fuzzy qualifiers are as follows:

Absolutely important (AV)

Very important (VI)

Important (I)

Slightly important (SI)

of little importance (LI)

Each question in this section is a manifestation of a criterion of concern in evaluating a proposal. Each question – 'How important is this indicator to this SCM?' will be given an answer according to the following scale:

Absolutely important (A~~V~~I) S_5
Very important (VI) S_4
Important (I) S_3
Slightly important (SI) S_2
of little importance (LI) S_1

Determining the domain of the fuzzy variables

The total allowable universe of a value is called the domain of a fuzzy set which can be both positive and negative. For this exercise the domain is positive and is defined as in Table 7.15.

Table 7.15 – Ranges and mean for the indicators

Fuzzy variables		Ranges	Mean
Absolutely important	(AV)	0.7-0.10	0.9
Very important	(VI)	0.5-0.9	0.7
Important	(I)	0.3-0.7	0.5
Slightly important	(SI)	0.1-0.5	0.3
Of little importance	(LI)	0-0.3	0.1

The domain takes the range from either 0 to 1 or 0 to 10. This arbitrary value can be provided by the decision-maker or the expert themselves. For this exercise, the value is provided by the decision-maker since there are 143 indicators to answer. The task of asking the evaluator to provide the range would prove too complicated not to mention risking putting them off by consuming too much time. The possibility of having too many ranges which were not within the expected range, further prove to be too complex to handle. For this reason, the range and mean used is based on Abdul Majid's (1997) study. The apex of the triangle shown in Figure 7.11 represents the mean of the ranges of values.

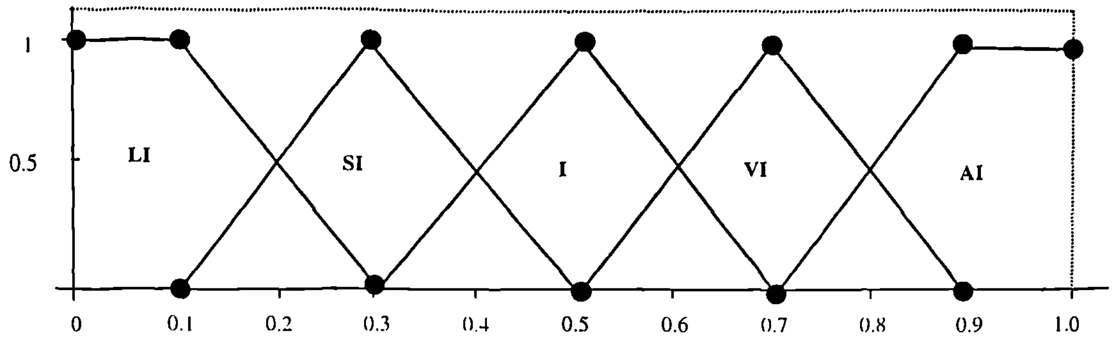


Figure 7.11 – Membership function for fuzzy variables 'IMPORTANCE'

The range used is 0.4 for the immediate membership functions and 0.3 *for the two* extremes. The use of the above scale provides a natural ordering that $s_i > s_j$ if $i > j$. Essentially the scale is ordered linearly implying that one scale is better than the other. The scale does not impose undue burden on the evaluator and experts will only circle the appropriate importance to each indicator.

Calculating the truth of linguistic quantified statements

The next step is calculating the truth statement that (Q y's are F) knowing truth (y is F), $\forall y \in Y$ ($\forall y$ = universal quantifier for all y). Based on Zadeh's calculus (since it is simpler and more transparent), the degree of importance *for each indicator is* determined. The example given below for the safety audit SCM illustrates how the degree of importance is calculated for all indicators.

Example A

- First, list out the frequency of ranking given by all of the respondents for the safety audit SCM as follows:

Table 7.16 – Frequency ranking by respondents – survey results

	Carrying out safety audit	**AI**	**VI**	**I**	**SI**	**LI**	total
I_1	Participation in safety audit from different levels	9	11	5	2	15	42
I_2	Pre-audit training	6	7	21	4	4	
I_3	Frequency of safety audit at least once a month	5	9	16	6	6	
I_4	Safety audit analysis	7	18	12	1	4	
I_5	Feedback of analysis to site management	20	14	4	2	2	
I_6	Action plan on safety audit analysis	14	16	7	3	2	

- Calculate the degree of membership for each of the indicators
  - Participation in safety audit from different levels (I_1)

$$= \frac{(9x0.9)+(11x0.7)+(5x0.5)+(2x0.3)+(15x0.1)}{42} = 0.49$$

  - Pre-audit training (I_2)

$$= \frac{(6x0.9)+(7x0.7)+(21x0.5)+(4x0.3)+(4x0.1)}{42} = 0.53$$

  - Frequency of safety audit at least once a month (I_3)

$$= \frac{(5x0.9)+(9x0.7)+(16x0.5)+(6x0.3)+(6x0.1)}{42} = 0.50$$

  - Safety audit analysis (I_4)

$$= \frac{(7x0.9)+(18x0.7)+(12x0.5)+(1x0.3)+(4x0.1)}{42} = 0.75$$

  - Feedback of analysis to site management (I_5)

$$= \frac{(20x0.9)+(14x0.7)+(4x0.5)+(2x0.3)+(4x0.1)}{42} = 0.73$$

  - Action plan on safety audit analysis (I_6)

$$= \frac{(14x0.9)+(16x0.7)+(7x0.5)+(3x0.3)+(2x0.1)}{42} = 0.68$$

The same calculation process is carried out for the remaining 142. Table 7.17 shows the end results as calculated for all 143 indicators

Table 7.17 – Degree of membership for each indicator – survey results

Safety control measures/Indicators	Degree of membership for each indicator
Carrying out safety audit	
Participation in safety audit from different levels	0.49
Pre-audit training	0.53
Frequency of safety audit at least once a month	0.50
Safety audit analysis	0.75
Feedback of analysis to site management	0.73
Action plan on safety audit analysis	0.68
Up to-date safety documents	
Communicate to personnel	0.78
Review safety document	0.67
Provide up-to-date safety documents	0.67
Pre-tender risk assessment	
Carry out pre-tender risk assessments	0.64
Communicate health and safety plan to site	0.76
Review finding in health and safety plan	0.64
System for reporting of accidents/incidents	
Communicate procedures to personnel	0.74
Trained personnel to take report details	0.64
Record all reports	0.67
Conduct investigation on all reports	0.60
Reporting analysis	0.63
Review repeated occurrences	0.73
System for reporting near misses	0.68
Communicate procedures to personnel	0.57
Trained personnel to take report details	0.60
Record all reports	0.54
Conduct investigation on all reports	0.60
Reporting analysis	0.70
Review repeated occurrences	
Safety policy	
Communicate safety policy to personnel	0.70
Policy relates to company objectives	0.70
Review safety policy where necessary	0.60
Signed by responsible director	0.70
Safety meeting with supervisors	
Frequency of meeting at least once a week	0.60
Record attendance	0.59
Review any substandard work/incidents	0.70
Communicate actions highlighted during meeting to relevant persons	0.70
Senior management involvement	0.72

Table 7.17 (continued)

Safety control measures/Indicators	Degree of membership for each indicator
Safety meeting with specialist-contractors	
Frequency of meeting at least once a week	0.58
Discuss work progress, health and safety issues	0.66
Record attendance	0.60
Review any substandard work/incidents	0.68
Communicate actions highlighted during meeting to relevant persons	0.70
Choosing competent specialist-contractors	
Communicate company health and safety expectation to prospective specialist-contractors	0.71
Specialist-contractors submit health and safety requirement during pre-tender stage	0.65
Pre-qualification ability questionnaires	0.61
Health and Safety Committee	
HSC composed from all levels of personnel	0.58
Develop correction and improvement procedures	0.55
Develop action plan for compliance with regulations	0.76
Develop action plan for project accountability	0.41
Regularly review the company safety performance	0.59
Review and evaluate company procedures and implementation	0.58
Full time safety Officer	
Full time (> 75%) on project site	0.44
SO competent & trained	0.80
Responsible for training, advice & inspections	0.69
Responsible for overseeing all reporting of accidents/incidents and near misses	0.64
Carry out safety performance assessment on site	0.69
Induction training	
Induction for all personnel on first day of work	0.80
Comprehensive course content	0.71
Not more than one working day length	0.62
Use written material & visual aids	0.61
Issue of PPE where necessary	0.65
Safety booklet handed to attendees	0.62
Conduct tour of work place	0.56
Carry out evaluation after induction	0.61
Planned inspection	
Planned inspection at least once a day	0.58
By competent and trained supervisors	0.69
Plan what to inspect	0.60
Review any substandard performance	0.68
Written report on all sub-standard situations	0.59
Communicate sub-standard work report to specialist-contractors	0.72
Follow-up defines who, how and when	0.70

Table 7.17 (continued)

Safety control measures/Indicators	Degree of membership for each indicator
Carry out Toolbox talks	
By competent and trained supervisor	0.69
Talk focus on gang's particular work	0.71
Frequency of talk at least daily for pre tasks	0.51
Frequency of talk at least weekly for general safety	0.51
Review task, method statements & work permits	0.66
Carry out risk assessment before work commences	0.74
Initiate actions on all sub-standard situations	0.68
Record all talks	0.62
Construction risk analysis	
Communicate construction health and safety plan	0.73
Carry out safety briefing before work s commence	0.75
Review risk analysis with respective workers	0.66
Revise the analysis if necessary	0.65
Communicate risk analysis reports for future orientation and training programmes	0.61
Method statements	
Management to identify critical area that has inherent or significant risk in its execution	0.80
Communicate method statements to respective and responsible workers	0.81
Provide formal training if required	0.76
Ensure contingencies are planned for	0.71
Permit to work system	
Design risk assessments to identify type of permit required	0.67
Permit to be issued by trained & appointed person	0.72
Permit must be properly authorised and accepted before work commences	0.74
Incorporate permits to work into method statement	0.68
No one except the issuer or identified management supervisor can cancel, alter or override the work permit	0.66
Machinery & equipment in working condition	
Only trained/skilled operators to handle machinery & equipment	0.82
All machinery manuals in place for the operator or maintenance to use	0.62
Housekeeping	
Plan storage area by reference to construction programme	0.68
Provision of outside & inside storage area	0.63
Conduct housekeeping checks	0.64
Daily clean-up	0.62

Table 7.17 (continued)

Safety control measures/Indicators	Degree of membership for each indicator
Material Safety and Health Data Sheet	
Communicate MSHDS to affected personnel	0.70
Training for hazardous materials	0.67
Review & up-to-date MSHDS if required	0.61
HQ to keep master copy of MSHDS	0.51
Emergency response system	
Communicate emergency system to all	0.76
Provide training for emergency situation	0.72
Carry out drills	0.64
Suggestions system	
Communicate procedures to all personnel	0.68
Formal and informal system for making safety suggestions, recommendations or improvements	0.60
Reward scheme for any proposal, suggestion or improvement	0.48
Communicate all accepted proposals	0.73
Communication	
Clear chain of command throughout the project	0.79
Communicate all instruction during meetings	0.63
Instruction can be verbal or written	0.60
Safety promotion	
Communicate safety message through posters & boards	0.54
For signs & guarding, follow standard codes and colours	0.61
Posters and boards must be seen by everyone at least once a day	0.46
Place safety poster at entrance	0.70
Change safety posters at least fortnightly	0.64
On going training	
Management to provide the following training/course for any relevant personnel:	
• Induction course	0.81
• Pre-audit training	0.58
• Training for undertaking reporting of accident/ incident and near misses	0.60
• Training to undertake high risk jobs	0.78
• Emergency response system	0.71
• Training for handling hazardous material	0.70
• Risk assessment training	0.70

Table 7.17 (continued)

Safety control measures/Indicators	Degree of membership for each indicator
Safe behaviour exists	
Continuous message of safety as important exists	0.73
Safe behaviour exists on site	0.74
Safe behaviour related to equipment, tools and machinery	0.73
Safe working environment	
Management to provide safe & conducive working environment	
• Proper guards and support	0.79
• Proper illumination	0.76
• Proper ventilation	0.74
• Work place not congested	0.69
• All tools and equipment in working condition	0.76
• Orderly work place	0.71
• Proper warning and detection system	0.69
• Suitable and sufficient welfare facilities such as sanitation, drinking water, changing room etc	0.75
Proper health care	
All personnel entitled to proper medical care & attention	0.71
Formal procedures to monitor industrial hygiene	0.63
Pre-employment questionnaire	0.59
Appoint qualified first aider on site	0.76
Motivation	
Encourage active participation of personnel in decision making	0.70
Reward good safety performance	0.58
Implement appraisal system for recognition of good safety performance	0.60
Recruiting the right person	
Personnel have the right skills and knowledge	0.78
Reference from previous employer	0.57
Probationary period for new personnel	0.58

The degree of membership (from Table 7.17) reveals the membership value for each indicator. Based on Table 7.17, using the safety audit SCM, the lowest and the highest membership in the group (I_1 and I_5), the results can be interpreted as follows:

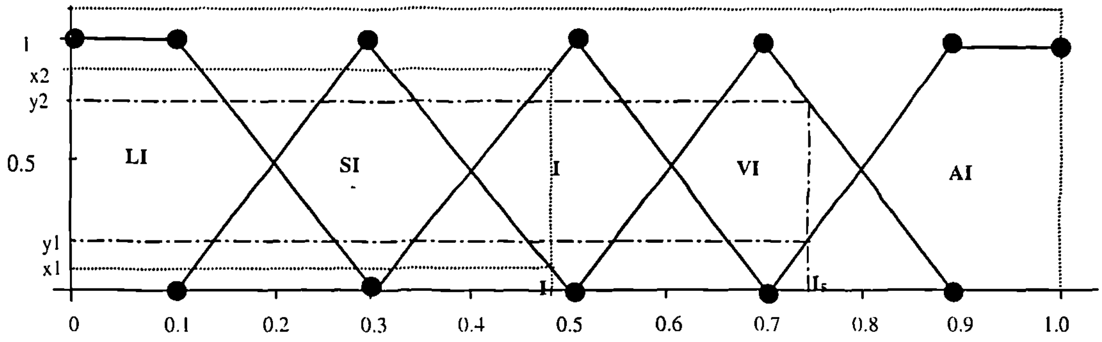


Figure 7.12 – Example of membership function for safety audit SCM indicators I_1 and I_5 for fuzzy variable 'IMPORTANCE'

From the above figure, where I_1 the mean score is 0.49, its membership value in the IMPORTANCE fuzzy set is x1 and x2. This means that I_1 has a low membership for the 'slightly important' group – x1, but a high degree of membership for the 'important' group - x2. This indicator falls between 'slightly important' and 'important'. The degree of membership determines how strong the level of importance is. For the case of I_5 , a mean score of 0.75 is obtained and the same principle is applied. The degree of membership is low for the 'absolutely important' – y1, but high for the 'very important' – y2. This means that it can be categorised as between 'very important' and 'absolutely important'. In a sense the degree of membership in a fuzzy set can be viewed as the level of compatibility between the response and the level of importance.

Calculation of the fuzzy logic based calculus of linguistically quantified propositions.

From here, the weight of the safety control measures is calculated using the fuzzy logic based calculus of linguistically quantified propositions. The following example for the calculation of weight for the safety audit SCM is explained.

Example B

Property F is defined as a fuzzy set in Y.

Y = {I_1, I_2 , I_3 ,I_4, I_5, I_6}

F = {IMPORTANT}

F = 0.49/ I_1 + 0.53/ I_2 + 0.50/ I_3+ 0.75/ I_4+ 0.73/ I_5 + 0.68/ I_6,

which means that indicator I_1 is important to degree 0.49; I_2 is important to degree 0.53; I_3 is important to degree 0.50; I_4 is important to degree 0.75; I_5 is important to degree 0.73 and; I_6 is important to degree 0.68.

The value of truth (*Q y*'s are *F*) is determined as follows:

$$r = \frac{\Sigma Count(F)}{\Sigma Count(y)} = \frac{1}{n}\sum_{1}^{n} \mu_F(y_1), \qquad (1)$$

$$r = \frac{1}{6}(0.49 + 0.53 + 0.50 + 0.75 + 0.73 + 0.68)$$

$$r = 0.61$$

Truth (*Q y*'s are *F*)

$$= \mu_Q(r) \qquad (2)$$

$$= \mu_{'most'}(r)$$

$$= \mu_{'most'}(0.61)$$

The result $\mu_{'most'}(0.61)$ indicates that the degree of truth that all six indicators are important to the safety audit SCM is 0.61. Based on Table 15, this mean that it falls within the 'important' and 'very important' category. The next step is to measure the quantifier 'most'. Here, the Q = 'most' is defined according to Zadeh's definition as explained in Section 6.2.2 and is as follows:

$$\mu_{'most'}(r)\begin{cases} 1 & \text{for } r \geq 0.8, \\ 2r - 0.6 & \text{for } 0.3 < r < 0.8, \\ 0 & \text{for } r \leq 0.3, \end{cases} \qquad (3)$$

Therefore, in this example for safety audit SCM, the value of truth is

= (2 x 0.61)-0.6

=0.62

i.e. the degree that 'most' indicators are important to safety audit SCM is 62%. In other words, for this SCM, 62% was obtained to achieve the linguistic quantifier 'most'.

The above analysis has enabled the degree of truth concerning the importance of the indicators for each SCM to be determined as in Table 7.18. This will also constitute the weight used for each SCM in SPMT.

Table 7.18 – Measure truth of importance for each SCM using fuzzy linguistic quantifier – survey results

Safety control measures	(r)	$\mu_{'most'}(r)$
Safety audit	0.61	0.62
Up-to-date safety documentation	0.69	0.78
Pre-tender risk assessment	0.68	0.76
Procedures for reporting accidents/incidents	0.67	0.74
Procedures for reporting near misses	0.61	0.62
Up-to-date safety policy	0.69	0.78
Safety meeting with supervisors	0.66	0.72
Safety meeting with sub-contractors	0.64	0.68
Selection of sub-contractor based on safety issues	0.66	0.72
Health & Safety Committee	0.58	0.56
Safety officer	0.65	0.70
Induction training	0.65	0.70
Site inspection	0.65	0.70
Tool-box talks	0.64	0.68
Construction risk analysis	0.68	0.76
Method statements	0.77	0.94
Permit-to-work system	0.69	0.78
Machinery & equipment in safe working condition	0.72	0.84
Good housekeeping	0.64	0.68
Material Safety Health Data Sheet	0.62	0.64
Emergency response system	0.71	0.82
Suggestion system	0.62	0.64
Communication	0.67	0.74
Safety promotion	0.59	0.58
Training	0.70	0.80
Safe behaviour	0.73	0.86
Safe working environment	0.74	0.88
Effective health care	0.67	0.74
Motivation to safe behaviour	0.63	0.66
Recruiting the right person	0.64	0.68

7.5 SUMMARY

1. A 30% response rate was achieved for Survey I which comprised of 75% from the Principal Contractors and 25% from the Specialist Contractors. A total of 63 returned questionnaires were used to validate findings of this research.

2. Survey I identified all of the safety control measures that affect safety performance on construction sites. The Spearman's correlation test conducted on the group of factors (Tables 8.1 to 8.9) highlight the five groups of factors which have significant agreement in ranking between the PC and SC group. They are as follows:
   - safety audit;
   - engineering control;
   - communication;
   - safety culture; and
   - health.

   The other groups of factors accept the null hypothesis at a confidence level of 95%. Although there was no agreement in ranking in some categories, the objective of establishing the sub-factor for each factor was achieved using the PC's ranking.

3. Survey II tested 303 indicators under all of the sub-factors from Survey I. These indicators were sent out to 14 ECI Safety Task Force members to provide feedback, 10 of which responded. From here, 143 indicators were identified from the experts' ranking and suggestions. Using the expert opinion method, this long and time consuming task proved to be successful in developing the indicators to be compact, precise and exact.

4. The *indicators identified* from Survey II were then further validated by a larger sample consisting of two groups– 61 companies from top UK contractors and 90 companies from top mainland European companies. The response rate was encouraging for the UK group but low for the European group possibly due to the language barrier.

5. The analysis performed in Survey III enabled information on the scenario of the companies' involvement in measuring safety performance to be gathered. 86% of the respondents were found to carry out safety performance assessment. All of these adopted both the reactive and proactive methods of assessments with 86% of the respondents developing their own in-house system. This figure highlights the absence of a standard system that can be used by industry.

6. From Survey III, 41% of respondents carry out safety performance assessment every month, with 37% spending one person-day on each assessment. When asked about the involvement of human resource, only site management and safety management teams are actively involved, the remaining teams having peripheral involvement. Only 18% of operatives respondents were involved with the assessment process.

7. The method adopted to carry out the performance assessment comprises 26% checklists, 25% observation methods, 24% document checks, 15% interviews and 10% questionnaires. From this point only 40% of the respondents communicate the assessments results to personnel on site although 87% take action on the assessments carried out, record the actions and review it when necessary.

8. The SCMs are grouped into three categories - 'hardware', 'software and 'people' – and then ranked. The ranking was carried out to examine the difference between both groups.

9. The level of importance of the indicators was measured using the fuzzy membership approach. This approach was able to measure the degree of truth to which each indicator was important to the SCM. All the results obtained showed that the degree of membership was within the range of 'slightly important' to 'absolutely important'.

10. From the above results, the weights for each SCM were determined. This was achieved using Zadeh's linguistic quantifier approach where the quantifier used was 'most'. The results obtained were interpreted according to the OMAX score matrix as explained in Chapter 4.

11. The results obtained through the three levels of surveys have helped to develop the SPMT. From here, all the indicators and SCMs chosen will be built into SPMT for further testing so as to measure safety performance on construction sites.

CHAPTER 8

SAFETY CONTROL MEASURES OF SPMT

8.1 INTRODUCTION

The most important aspect of measuring safety performance on site is knowing exactly what to measure and only by measuring the correct factors will one obtain a true picture of safety performance on site. Historically, there are many approaches that have been used. This thesis has shown that reactive measures are insufficient, emphasis should be placed on proactive measures.

Choosing the right proactive safety control measures (SCMs) is also a difficult task and it is important to select ones that:

a) are attributes of an operating system;
b) relate to the specific occurrence; and
c) can be controlled.

The chosen SCM has to be both comprehensive and generic and must be applicable to any site at any time of the construction process. In addition, Tarrants (1980) stated that the chosen SCMs must be able to represent the attributes at a microscopic level instead of macroscopic one. He claimed that measurement practices and techniques that are oriented towards the microscopic level will meet the needs at macroscopic level.

This chapter will present the minimum requirements for all thirty SCMs. These are presented as series of bullet points. These requirements were derived from extensive literature reviews and surveys which are discussed in Chapters 5, 6 and 7. Appendix 8.1 explains in more detail the best practice for each SCM. In order for projects to score well using SPMT, all thirty SCMs must exist on site and be implemented effectively and communicated efficiently to the relevant personnel.

8.2 SAFETY CONTROL MEASURES

Safety audit

- participation in safety audit of all personnel including operatives and specialist-contractors;
- provide pre-audit training for all personnel participating in safety audit;
- complete safety audit at least once a month;
- carry out safety audit analysis after every audit;
- feedback safety audit analysis to site management; and
- prepare action plan based on safety audit analysis.

Up to-date safety documents

- communicate all relevant safety documents to respective personnel during both pre-construction and construction phase;
- review safety document from time to time to incorporate any changes; and
- provide up-to-date safety documents to site management.

Pre-tender risk assessment

- carry out pre-tender risk assessment as required by legislation such as the CDM Regulations;
- communicate pre-tender health and safety plan to site; and
- review findings in health and safety plan before commencing work.

System for reporting of accidents/incidents

- communicate reporting procedures to all personnel especially requirements of RIDDOR 95;
- train personnel to report details;
- record all reporting including fatality, lost day cases, doctor's cases, first-aid cases, property damage and environmental damage;
- conduct investigation on all reports;
- reporting analysis for the investigations;
- review repeated occurrences.

System for *reporting near misses*

- communicate reporting procedures to all personnel;
- train personnel to report details;
- record all reporting;
- conduct investigations on all reports;
- report analysis for the investigations; and
- review repeated occurrences.

Safety policy

- management must communicate safety policy to personnel;
- safety policy must
  - relate to company objectives;
  - be signed by responsible director; and
- management must review safety policy where necessary.

Safety meeting with supervisors

- hold meetings at least once a week;
- record attendance at meetings;
- review any substandard work/incidents;
- communicate actions highlighted during meetings to relevant persons; and
- involve senior management.

Safety meeting with specialist-contractors

- hold meetings at least once a week;
- discuss work progress, health and safety issues;
- record attendance at meetings;
- review any substandard work/incidents; and
- communicate actions highlighted during meetings to relevant persons.

Choosing competent specialist-contractors

- communicate company health and safety expectations to prospective specialist-contractors;

- specialist-contractors must submit health and safety requirements during pre-tender stage; and
- management must prepare pre-qualification ability questionnaires for prospective specialist-contractors.

Health and Safety Committee (HSC)

- HSC composed from all levels of personnel;
- HSC's function to include
    - developing correction and improvement procedures;
    - developing action plan for compliance with regulation;
    - developing action plan for project accountability;
- HSC must regularly review and evaluate
    - the company safety performance; and
    - company procedures and implementation.

Full time safety officer (SO)

- All SOs must be
    - full time (> 75%) on project site;
    - competent & trained;
- SO to be responsible for
    - training, advice & inspections;
    - overseeing all reporting of accidents/incidents and near misses; and
    - carrying out safety performance assessments on site.

Induction training

- conduct induction training for all personnel on first day at work site;
- the induction training sessions
    - be comprehensive in content;
    - last not more than one working day;
    - use visual and written material;
    - issue PPE where necessary;
    - issue safety booklets to attendees;
    - include a tour of work place; and

- management must carry out evaluation after induction to ensure that all attendees understood the training content.

Planned inspections

- inspections must be carried out by competent and trained supervisors;
- all inspections must be
  - carried out at least once a day;
  - planned;
- All substandard performance must
  - be reviewed;
  - result in a report;
  - be communicated to specialist-contractors; and
- all follow-ups regarding sub-standard work must define who, how and when.

Toolbox talks

- toolbox talks must be carried out by competent and trained supervisors;
- all toolbox talks must
  - focus on gang's particular work;
  - be held at least daily for pre tasks;
  - be held at least weekly for general safety;
  - review tasks, method statements & work permits;
  - include pre-work risk assessment;
  - be recorded; and
- supervisors must initiate actions on all sub-standard situations; and

Construction risk analysis

- management must communicate construction health and safety plan to all relevant personnel;
- supervisors to
  - carry out safety briefing before work commences;
  - review risk analysis with respective workers;
  - revise the analysis if necessary; and

- management to communicate risk analysis report for future orientation and training programmes.

Method statements

- management must
  - identify critical activities that have inherent or significant risks in their execution;
  - communicate method statements to responsible workers;
  - provide formal training if required; and
  - ensure contingencies are planned in case the initial method statements do not work properly.

Permit to work system

- permits to be issued only by trained & appointed persons;
- design risk assessment to identify type of permit required;
- all permits must be properly authorised and accepted before work commences;
- permits must incorporate method statements; and
- no one except the issuer or identified management supervisor can cancel, alter or override the work permit.

Machinery & equipment in working condition

- only trained/skilled operators to handle all machinery & equipment; and
- all machinery manuals must be in place for the operator or maintenance to use.

Housekeeping

- management must
  - plan storage areas by reference to construction programme;
  - provide outside & inside storage areas;
  - daily clean-up by all workers including specialist-contractors; and
  - conduct housekeeping checks.

Material Safety and Health Data Sheet (*MSHDS*)

- management
  - must communicate *MSHDS* to affected personnel with specific information on chemicals that they may come in contact with;
  - provide training for hazardous material if necessary;
  - review & up date MSHDS if required; and
- HQ to keep master copy of updated MSHDS.

Emergency response system

- management to
  - communicate emergency system to all personnel especially during induction training;
  - provide training for emergency situations such as accidents, property damage, public demonstrations, fire and bomb threats; and
  - carry out drills for the above situations at least once throughout the project.

Suggestions system

- management to
  - inform all personnel about the formal and informal system for suggestion systems such as suggestion box or suggestion form;
  - visibly reward all new creative ideas;
  - communicate all accepted proposals to all on site; and
  - explain non-accepted proposals to the proposees.

Communication

- clear chain of command must exist throughout the project among all levels of personnel;
- all instructions must be communicated during formal meetings; and
- good practice required in all verbal or written instructions.

Safety promotion

- management must communicate safety message through posters & boards;
- all signs & guarding must follow standard codes and colours coding;
- all posters and boards must be
  - seen by everyone on site at least once a day;
  - placed at the site entrance; and
  - changed at least fortnightly.

On going training

- management to provide the following training/courses for any relevant personnel:
  - induction training,
  - pre-audit training;
  - training for reporting of accidents/incidents and near misses
  - emergency response systems;
  - training for high risk jobs;
  - training for handling hazardous materials;
  - risk assessment training;
- management must provide refresher training where necessary; and
- carry out evaluations after a training session to ensure understanding of training.

Safe behaviour exists

- management to continuously communicate safety message to all personnel;
- safe behaviour exists on site related to
  - equipment;
  - tools; and
  - machinery.

Safe working environment

- management to provide safe & conducive physical working environment such as proper guards and supports, proper ventilation and others; and
- physical workplace must support safe work as required by law.

Proper health care

- all personnel must have access to proper medical care & attention;
- formal procedures to monitor industrial hygiene must exist on site;
- pre-employment questionnaire to be completed by all new employees on site; and
- there must be at least one qualified first aider on site.

Motivation

- management must
  - encourage active participation of personnel in decision making;
  - implement an appraisal system for recognition of good safety performance; and
  - reward good safety performance by public recognition, authority or promotions.

Recruiting the right person

- management must;
  - recruit only personnel who have the right skills and knowledge to perform the task required
  - obtain references from previous employer; and
  - implement probationary period for new personnel to ensure only employees that observe company rules are retained.

8.3 SUMMARY

1. The SCMs explained in this chapter were developed through a rigorous process starting with a literature search followed by three levels of survey. Once the SCMs were identified, another literature search was conducted this time looking at best guidance and best practice for each of the chosen SCMs.

2. The thirty SCMs discussed in this chapter were used to develop SPMT to create a comprehensive and generic tool in measuring safety performance on construction sites.

CHAPTER 9

SPMT IMPLEMENTATION AND VALIDATION

9.1 INTRODUCTION

The testing of SPMT was necessary to fulfil the objectives of this study, namely: to implement SPMT on on-going projects and evaluate the effectiveness of the tool to measure and improve safety on site. In order to fulfil both objectives, it was necessary to find sites that were willing to participate in the testing. There were many problems encountered in trying to identify sites to participate. Some project teams were just not interested, others did not fully understand the objectives, others explained that they were too busy with tight schedules or that they already had a performance measurement system.

Nevertheless, three companies agreed to participate, namely Birse Construction Ltd, Mowlem Midlands and Kvaerner Process. The following sections describe the sites involved, how SPMT was implemented and the results of the site tests.

9.2 CASE STUDY OF THE SITES

In all four sites were used in the trial. These projects are briefly described as follows:

Name of project	Expansion at the Grangemouth/Teeside ethylene pipeline, the construction of two petro-chemical plants and associated infrastructure at the BP's Hull site.
Contract value	This information was not provided.
Contract period	November 1998 – June 2001
Project description	

- construction of a new vinyl acetate monomer (VAM) plant at Hull;
- construction of 220kta ethanol and ethyl acetate (ETAC) plant at Hull;
- construction of a scale ETAC pilot plant at Hull's research centre;
- construction of associated core offsites facilities (COS); and
- integration into Hull site work infrastructure.

Name of project	Manchester United Fan Club renovation
Address	Manchester
Contract value	£25.3m
Contract period	88 weeks
Due completion	December 2000
Project description	

Extension to the existing East and West stand to provide new tiers of terrace seating whilst maintaining use of the existing stands for football viewing.

Name of project	Derby sewage treatment works (STW) reconstruction – phase 1
Address	Derby sewage treatment works Derby
Contract value	£54.0M
Contract period	104 weeks
Due completion	August 2001

Project description

- construction of 8 aeration lane and blower galleries;
- 10 final settlement tanks;
- sludge thickening and digestion plant;
- pumping stations and pipelines;
- a new workshop/control building; and
- road bridge over the River Derwent.

Name of project	Retirement homes
Address	Redditch, Worcestershire
Contract value	£3,579,000
Contract period	10 months
Due completion	September 2000

Project description

- 3 storey split level timber framed building to provide living accommodation for 58 single retired persons.
- the building will house a restaurant with dance floor, spa, exercise room, shop, activity room, laundry, craft room, computer room and separate greenhouse;
- the building will be brick clad to give the impression of traditionally built structure; and
- work in the ground was very extensive as the ground was of poor load bearing capability and steeply sloping.

9.3 CARRYING OUT SITE TESTING

9.3.1 Pilot testing

All together there were five respondents for the SPMT pilot test selected from construction-related staff at Loughborough University. Each person reviewed one category of respondent's questionnaire using the computer. Comments were written down covering each unsure or ambiguous question. As well as providing detailed feedback on individual questions, the pilot study established the following more general points regarding SPMT:

- the tool was easy to use;
- the instructions were clear;
- the navigation buttons within SPMT were easy to follow and consistent;
- all the contents presented were easy to understand; and
- all of the respondents were able to use the tool without any help.

The pilot testing was also used to indicate how long each category of respondents would take to complete their sections. Below are the estimated times for each category of respondents:

Personnel	Estimated time (hours)
HQ management	2
Site management	3
Supervisor	2
Operatives	1
Specialist contractor – Management	1

9.3.2 Site testing

Once the amendments were completed based on the pilot study reviewer's remarks, SPMT was ready to be fully tested. Appointments were made with each company managing the sites. The management was briefed as follows:

- the objectives of SPMT;
- how SPMT works;
- the amount of human resources required;

- the estimated time needed for each category of respondent to answer the questions;
- the need for a computer with MS Access;
- the input from HQ management; and
- how to carry out document checks and observations.

From the discussions, management raised the issue of the difficulty of asking the site-based participants to sit in front of the computers for the following reasons:

- personnel might be put off by using the computer;
- personnel might feel inferior because lack of knowledge about computers;
- the presence of the management personnel near the respondents would create an uncomfortable situations for the respondents; and
- the need for a computer for at least 10 hours for each assessment would be difficult to provide.

To overcome the above drawbacks, it was agreed with the management that a paper version would be more appropriate with data entered on to the computer later. Thus a paper version (Appendix 9.1) was adopted for the trials for the following reasons:

- any category of respondents can answer the questionnaires anywhere;
- the HQ management were able to answer the relevant questionnaire from the HQ office and send it to site for input into the computer;
- all the participants could be briefed together and then respond individually in the same room;
- it would be easier to implement; and
- no supervision would be required.

The management was given two weeks to complete the paper version questionnaires. Once the responses were returned, all answers were input into the computer. A report on the analysis was carried out. Once the reports were ready, meetings were held with all respective site managers or head office managers. The meetings were mainly to brief the companies of the following:

- the SPMT Index;
- the analysis of safety control measures (SCMs) performance;
- the respondents influence on SCMs;

- highlighting the weak SCMs that needs urgent attention;
- reasons for the poor performance of the weak SCMs;
- highlighting the excellent SCMs and reasons for its excellent performance; and
- a need for periodic assessment to monitor on the weaker SCMs.

Notwithstanding the decision to use hardcopy for the tests, SPMT has the future potential as an information communication technology (ICT) tool. The construction industry is renowned for its reluctance to embrace new technology but ICT will soon infiltrate all companies both small and large. The future use of SPMT may even be designed as a hand held computerised organiser or personal digital assistant (PDA). PDAs can store information which can then be swapped between sites and the office. This will definitely benefit SPMT for its practicality for site usage.

9.4 RESULTS OF SITE TESTING

For the purpose of anonymity, the four sites will be called Site A, Site B, Site C and Site D which bear no correlation to section 9.2. This section will discuss the results of the SPMT trials. The detail explanation for calculating the scores of SPMT has been discussed in Chapter 4 - Section 4.4. The following discussions will focus on Site A results as the pilot site. The full results for all sites are found in Appendix 9.2.

SPMT Index

The SPMT Index achieved for this project was 70% as shown in Figure 9.1 (see section 4.4.3 for detailed explanation for calculating SPMT Index). This places it within the 'very good' category based on the table below:

Scale (%)	**Indication of safety culture**
90-100	Excellent
70-89	Very good
50-69	Good
30-49	Moderate/poor – need to improve the safety culture
0-29	Unacceptable – need to take urgent action

Performance score	Carrying out safety audit	Up-to-date safety document	Pre-tender risk assessment	System for reporting acc/inc	System for reporting near miss	Safety policy	Meeting with supervisor	Meeting with SC	Choosing competent SC	HSEComm
	86	70	80	190	180	120	150	130	50	0
10	166	70	80	329	284	150	170	170	60	130
9	150	63	72	296	256	135	153	153	54	117
8	133	56	64	263	227	120	136	136	48	104
7	116	49	56	230	199	105	119	119	42	91
6	100	42	48	197	170	90	102	102	36	78
5	83	35	40	164	142	75	85	85	30	65
4	66	28	32	132	114	60	68	68	24	52
3	50	21	24	99	85	45	51	51	18	39
2	33	14	16	66	57	30	34	34	12	26
1	17	7	8	33	28	15	17	17	6	13
0	0	0	0	0	0	0	0	0	0	0
Score	5	10	10	5	6	8	8	7	8	0
Weight	62	78	76	74	62	78	72	68	72	56
Total	310	780	760	370	372	624	576	476	576	0

Performance score	Full time SO	Induction training	Planned inspection	Tool-box talk	Construction risk analysis	Method statement	Machine and tools in safe operation	Work permit	Good housekeeping	MSHDS
	90	760	210	10	70	60	10	80	110	40
10	140	930	240	90	80	70	20	80	130	70
9	126	837	216	81	72	63	18	72	117	63
8	112	744	192	72	64	56	16	64	104	56
7	98	651	168	63	56	49	14	56	91	49
6	84	558	144	54	48	42	12	48	78	42
5	70	465	120	45	40	35	10	40	65	35
4	56	372	96	36	32	28	8	32	52	28
3	42	279	72	27	24	21	6	24	39	21
2	28	186	48	18	16	14	4	16	26	14
1	14	93	24	9	8	7	2	8	13	7
0	0	0	0	0	0	0	0	0	0	0
Score	6	8	8	1	8	8	10	10	8	5
Weight	70	70	70	68	76	94	84	78	68	64
Total	420	560	560	68	608	752	840	780	544	320

Performance score	Emergency response system	Suggestion system	Communication	Safety promotion	Training provided	Safe behaviour exist	Safe working environment	Proper health care	Motivate personnel	Recruiting the right people
	50	110	110	70	160	335	100	80	130	40
10	100	240	120	100	320	480	240	100	160	40
9	90	216	108	90	288	432	216	90	144	36
8	80	192	96	80	256	384	192	80	128	32
7	70	168	84	70	224	336	168	70	112	28
6	60	144	72	60	192	288	144	60	96	24
5	50	120	60	50	160	240	120	50	80	20
4	40	96	48	40	128	192	96	40	64	16
3	30	72	36	30	96	144	72	30	48	12
2	20	48	24	20	64	96	48	20	32	8
1	10	24	12	10	32	48	24	10	16	4
0	0	0	0	0	0	0	0	0	0	0
Score	8	4	9	7	5	6	4	8	8	10
Weight	82	64	74	58	80	86	88	74	66	68
Total	656	256	666	406	400	516	352	592	528	680

STANDARD DEVIATION	SPMT INDEX
2.50	70%

90-100%	Excellent
70-89%	Very good
50-69%	Good - need to improve
30-49%	Moderate/poor - need to improve harder
0-29%	Unacceptable - need to take urgent actions

Figure 9.1 - SPMT Index for Site A (test 1)

SCM performance

Table 9.1 presents the results of how each SCM performed. Chapter 4- Section 4.4.3 discusses how the SCMs are calculated. The results presented here enable the management to immediately identify the weak SCMs and take immediate actions based on the following table:

Scale	Indication of SCM
10	Excellent
8-9	Very good
6-7	Good
4-5	Moderate/poor – need to improve the safety culture
0-3	Unacceptable – need to take urgent action

Overall, 70% of Site A's SCMs performed within the performance category of 'good' and above (score 6-10). Four SCMs achieved an 'excellent' score. For Site A, there are two SCMs that needed immediate actions that are HSE Committee and toolbox talks.

Table 9.1 - SCMs performance score for Site A

Safety control measures	Score range	Score category
Safety documents Pre-tender risk assessment Permit-to-work system Recruiting the right person	10	Excellent
Meeting with supervisors Site inspection Choosing competent specialist-contractors Method statement Good housekeeping Construction risk analysis Communication Safety policy Induction training Proper health care Motivation	8-9	Very good
Meeting with specialist-contractors Safety promotion Safety officer Safe behaviour Procedures for reporting near misses Emergency response system	6-7	Good, but still need to improve SCMs
Training Safe working environment Safety audit MSHDS Procedures for reporting accidents/incidents Machinery & equipment in safe working condition Suggestion system	4-5	Need to work harder to improve the SCMs
HSE Committee Toolbox talks	0-3	Need urgent actions to improve SCMs

Respondents influence on the SCMs scores

SPMT also enabled management to analyse the influence of each category of respondents to each SCM. This exercise was not to put the blame on the low achieving respondents but rather as a step in helping to improve performance. Table 9.2 shows the results for Site A obtained from the SPMT assessment. By concentrating on the SCMs where there is a large discrepancies between the respondents scores this exercise clearly shows where there is agreement between different categories on one SCM. For example, from Table 9.3, for the 'up-to-date safety policy' SCM, the HQ management and site management scored 70% (46/66) and 75% (30/40) respectively but supervisors, operatives both scored 0% (0/20 and 0/20) while and specialist-contractors managers scored 50% (10/20). This may suggest that the HQ management and site management consider that the safety audit measures are in place, but for some reason, the site–based personnel do not.

A closer analysis of the questions will help the management to analyse the influence better.

HQ management's questions

1a	Does the HQ organise safety audits?	√
1b	Does the HQ staff participate in safety audits?	X
1c	If Yes, have you received any pre-audit training?	X
1d	How often do you carry out safety audits? *(tick only one box)*	
	• less than once a month	√
	• every month	
	• every 3 months	
	• every 4 months	
	• every 6 months	
	• ever once a year	
	• more than once a year	
1e	Does the HQ staff carry out safety analyses?	√
1f	Do you send any analyses and feedback to site management?	√
1g	Do you develop any action plan based on safety audit analyses?	X

Site manager's questions

1a	Do you participate in safety audits?	√
1b	If yes, did you receive any pre-audit training?	X
1c	Do you receive a safety audit analyses and feedback from HQ after every audit?	√
1d	Do you develop any action plan based on the safety audit analyses?	√

Supervisor's questions

1a	Do you participate in safety audits?	X
1b	If yes, did you receive any pre-audit training?	X

Operatives questions

1a	Do you participate in safety audits?	X
1b	If yes, did you receive any pre-audit training?	X

Specialist-contractor's questions

1a	Do you participate in safety audits?	√
1b	If yes, did you receive any pre-audit training?	X

From the questions asked, clearly it is obvious that there was no participation of the site-based personnel in safety audit at all. Also, there was no pre-audit training carried out to all categories before carrying out any safety audit.

Analysing the individual scores for each respondents category will also help management to recognise where the safety systems have been effective. Where there are high influence in the responses will indicate that the respondents have answered positively towards the questions asked. An example that can be demonstrated here is for the 'communication' SCM. From Table 9.2, all the respondents achieved 100% (10/10, 50/50, 20/20 and 20/20) except for the operatives that achieved 50% (10/20). Looking at the questions will help management to understand why the operatives did not score 100%.

HQ management's questions

1a	Do you have a clear chain of command among HQ management, site management, supervisors, operatives and specialist-contractors?	√

Site management's questions

1a	Do you have a clear procedure for conveying instructions?	√
1b	Does a clear chain of command exist among HQ management, site management, supervisors, operatives and specialist-contractors?	√
1c	Do you communicate instructions during meetings?	
1d	Do all instructions include both the following? (tick each box that applies)	√
	▪ verbal	√
	▪ non-verbal	√

Supervisors questions

1b	Does a clear chain of command exist among HQ management, site management, supervisors, operatives and specialist-contractors?	√
1c	Do you receive work instructions from management during meetings e.g. daily meetings or weekly meetings??	√

Operatives questions

1b	Does a clear chain of command exist among HQ management, site management, supervisors, operatives and specialist-contractors?	√
1c	Do you receive work instructions from management during meetings e.g. daily meetings or weekly meetings?	X

Specialist-contractors questions

1b	Does a clear chain of command exist among HQ management, site management, supervisors, operatives and specialist-contractors?	√
1c	Do you receive work instructions from management during meetings e.g. daily meetings or weekly meetings?	√

From the questions answers, it may seems that on this site, management only conveyed instructions formally during meetings to supervisors and specialist-contractors management, leaving out the operatives. To improve this SCM performance, management must ensure that all levels of relevant personnel are involved during conveying of instructions formally.

Table 9.2 – Respondents influence on the SCMs performance score for Site A

Safety control measures	Hq	Sm	Sup	Ops	Sc	Obs	Dc
Safety audit	70%	75%	0%	0%	50%		
Up-to-date safety documentation	100%	100%					100%
Pre-tender risk assessment	100%	100%					100%
Procedures for reporting accidents/incidents	71%	26%	75%	50%	100%		100%
Procedures for reporting near misses	59%	58%	75%	50%	100%		0%
Up-to-date safety policy	100%	0%	100%	50%	100%		100%
Safety meeting with supervisors		89%	100%				50%
Safety meeting with specialist-contractors		78%			71%		100%
Choosing competent specialist-contractors		75%			100%		
Health & Safety Committee		0%					
Safety officer	100%	44%					
Induction training		87%	91%	61%	87%	100%	
Site inspection		67%	100%		75%		0%
Tool-box talks			13%				0%
Construction risk analysis		50%	100%		100%		
Method statements		83%					100%
Permit-to-work system		100%					100%
Machinery & equipment in safe working condition.		50%					
Good housekeeping		90%				67%	
Material Safety Health Data Sheet	0%	100%	100%	0%	0%		
Emergency response system		50%		33%	67%		
Suggestions approach		38%	40%	20%	100%	0%	
Communication	100%	100%	100%	50%	100%		
Safety promotion		80%				60%	
Training	100%	78%	57%	14%	43%		0%
Safe behaviour				80%	73%	38%	
Safe working environment				13%	50%	63%	
Effective health care	100%	67%	100%	50%	100%		
Motivation personnel		75%	100%	75%	75%		
Recruiting the right people	100%	100%					

Hq	Head Office Management	Ops	Site operatives
Sm	Site office Management	Obs	Observations
Sup	Site supervisors	Dc	Document checks

Note: Percentage indicates the total score achieved by each category of respondents for each SCM over the maximum score possible.

Table 9.3 – Performance score achieved by each category of respondents over the maximum score possible for Site A

Safety control measures	Hq	Sm	Sup	Ops	Sc	Obs	Dc
Safety audit	46/66	30/40	0/20	0/20	10/20		
Up-to-date safety documentation	30/30	30/30					10/10
Pre-tender risk assessment	50/50	20/20					10/10
Procedures for reporting accidents/incidents	60/84	30/115	30/40	20/40	40/40		0/10
Procedures for reporting near misses	20/34	70/120	30/40	20/40	40/40		0/10
Up-to-date safety policy	60/60	0/20	20/20	10/20	20/20		10/10
Safety meeting with supervisors		54/60	90/90				10/10
Safety meeting with specialist-contractors		70/90			50/70		10/10
Choosing competent specialist-contractors		30/40			20/20		
Health & Safety Committee		0/130					
Safety officer	50/50	40/90					
Induction training		200/230	210/230	140/230	200/230	10/10	
Site inspection		20/30	160/160		30/40		0/10
Tool-box talks			10/80				0/10
Construction risk analysis		10/20	40/40		20/20		
Method statements		50/60					10/10
Permit-to-work system		70/70					0/10
Machinery & equipment in safe working condition.		10/20					
Good housekeeping		90/100				20/30	
Material Safety Health Data Sheet	0/10	30/30	10/10	0/10	0/10		
Emergency response system		20/40		10/30	20/30		
Suggestions approach		30/80	20/50	10/50	50/50	0/10	
Communication	10/10	50/50	20/20	10/20	20/20		
Safety promotion		40/50			30/50		
Training	10/10	70/90	40/70	10/70	30/70		0/10
Safe behaviour			160/200	146/200	30/80		
Safe working environment			10/80	40/80	50/80		
Effective health care	10/10	20/30	10/20	10/20	20/20		
Motivation personnel		30/40	40/40	30/40	30/40		
Recruiting the right people	30/30	10/10					

Hq Head Office Management
Sm Site office Management
Sup Site supervisors
Dc Document checks
Ops Site operatives

9.5 ANALYSIS AND DISCUSSIONS

The results obtained from the four sites were analysed. The discussion of results can be divided into four different approaches, namely

- comparisons within the four sites;
- comparison within the same company with two sites;
- comparison within the same sites with two testing; and
- comparison with reactive data from all sites.

9.5.1 Comparison within the four sites

SPMT Index

Sites	SPMT Index	Remarks
Site A	70%	Very good safety performance
Site B	74%	Very good safety performance
Site C	75%	Very good safety performance
Site D	64%	Good – need to improve

SPMT Index reveals the overall safety performance of the project for the four tested sites . From the analysis and based on SPMT Index grouping, the overall performance of the four sites demonstrates that Site C has the highest safety performance score. Site D achieved the lowest percentage with 64% which is classified as 'good'. All the sites achieving 'very good' safety performance can still work harder to strive for an excellent performance while Site D must work harder to improve its performance.

SCMs performance

In order to identify the weak and problem SCMs, an analysis was carried out to study the achievement of each SCM. Figure 9.2 illustrates how the four sites scored for the SCMs. The SCMs were grouped based on the performance scored as described in Section 9.4.

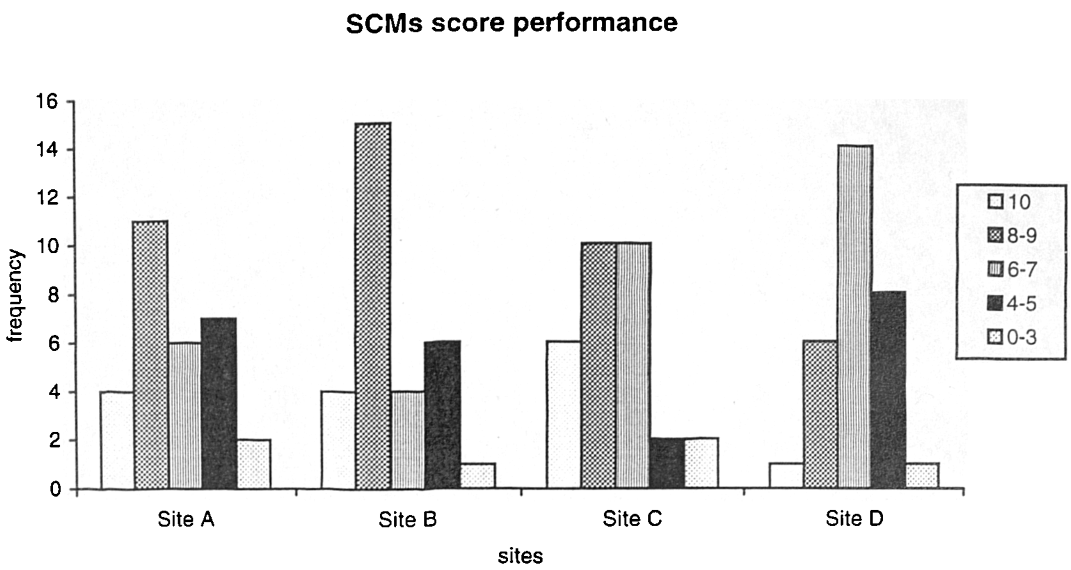


Figure 9.2 – Number of SCMs in performance each score category – survey results

Figure 9.2 illustrates that all sites have some SCMs rated 'excellent' (score 10) and some SCMs rated 'unacceptable' (score 0-3) which means immediate actions to be taken. This suggests that SPMT has been effective in that it has provided a spectrum of results.

For further analysis on the performance of each SCM, Table 9.4 presents how each SCM performed on the four sites. This helps to identify the weak SCMs among all thirty safety factors. To help with this discussion, Table 9.5 presents the mean score that each SCM achieved and the variance for each SCM among the four sites. The following discussions explain the trend of the scores of the SCMs.

Table 9.4 – SCMs performance scores for Site A, Site B, Site C and Site D – survey results

Safety control measures	Site A	Site B	Site C	Site D
Safety audit	5	8	6	6
Up-to-date safety documentation	10	4	8	7
Pre-tender risk assessment	10	3	7	5
Procedures for reporting accidents/incidents	5	7	6	6
Procedures for reporting near misses	6	5	4	4
Up-to-date safety policy	8	9	8	8
Safety meeting with supervisors	8	9	9	7
Safety meeting with specialist-contractors	7	4	9	8
Selection of specialist-contractors based on safety issues	8	8	10	6
Health & Safety Committee (HSC)	0	8	0	5
Safety officer	6	9	7	7
Induction training	6	8	6	6
Site inspection	8	4	9	8
Tool-box talks	1	10	8	7
Construction risk analysis	8	8	6	7
Method statements	8	10	10	10
Permit-to-work system	10	10	10	8
Machinery & equipment in safe working condition	5	5	10	5
Good housekeeping	8	7	10	5
Material Safety Health Data Sheet	5	8	7	6
Emergency response system	8	9	8	5
Safety suggestions	4	7	1	2
Communication	9	8	8	9
Safety promotions	6	9	7	8
Training	5	4	7	4
Safe behaviour	6	7	8	6
Safe working environment	5	9	9	7
Effective health care	8	8	6	7
Motivation to safe behaviour	8	8	5	4
Recruiting the right people	10	10	10	7

Table 9.5 – Means, standard deviation and variance performance score for site A, Site B, Site C and Site D – survey results

Safety Control measures	MEAN	STD DEV	VAR Site A	Var. Site B	Var. Site C	Var. Site D
Method statements	9.5	0.9	-1.5	0.5	0.5	0.5
Permit-to-work system	9.5	0.9	0.5	0.5	0.5	-1.5
Recruiting the right people	9.3	1.3	0.8	0.8	0.8	-2.3
Communication	8.5	0.5	0.5	-0.5	-0.5	0.5
Up-to-date safety policy	8.3	0.4	-0.3	0.8	-0.3	-0.3
Safety meeting with supervisors	8.3	0.8	-0.3	0.8	0.8	-1.3
Selection of specialist-contractors based on safety issues	8.0	1.4	0.0	0.0	2.0	-2.0
Good housekeeping	7.5	1.8	0.5	-0.5	2.5	-2.5
Safety promotions	7.5	1.1	-1.5	1.5	-0.5	0.5
Emergency response system	7.5	1.5	0.5	1.5	0.5	2.5
Safe working environment	7.5	1.7	-2.5	1.5	1.5	-0.5
Up-to-date safety documentation	7.3	2.2	2.8	-3.3	0.8	-0.3
Safety officer	7.3	1.1	-1.3	1.8	-0.3	-0.3
Site inspection	7.3	1.9	0.8	-3.3	1.8	0.8
Construction risk analysis	7.3	0.8	0.8	0.8	-1.3	-0.3
Effective health care	7.3	0.8	0.8	0.8	-1.3	-0.3
Safety meeting with specialist-contractors	7.0	1.9	0.0	-3.0	2.0	1.0
Safe behaviour	6.8	0.8	-0.8	0.3	1.3	-0.8
Induction training	6.5	0.9	-0.5	1.5	-0.5	-0.5
Tool-box talks	6.5	3.4	-5.5	3.5	1.5	0.5
Material Safety Health Data Sheet	6.5	1.1	-1.5	1.5	0.5	-0.5
Safety audit	6.3	1.1	-1.3	1.8	-0.3	-0.3
Pre-tender risk assessment	6.3	2.6	3.8	-3.3	0.8	-1.3
Machinery & equipment in safe working condition	6.3	2.2	-1.3	-1.3	3.8	-1.3
Motivation to safe behaviour	6.3	1.8	1.8	-1.8	-1.3	-2.3
Procedures for reporting accidents/incidents	6.0	0.7	-1.0	1.0	0.0	0.0
Training	5.0	1.2	0.0	-1.0	2.0	-1.0
Procedures for reporting near misses	4.8	0.8	1.3	0.3	-0.8	0.8
Safety suggestions	3.5	2.3	0.5	3.5	-2.5	-1.5
Health & Safety Committee (HSC)	3.3	3.4	-3.3	4.8	-3.3	1.8

Mean score of SCMs

The mean score can be grouped based on its dispersion with the minimum difference between each mean score as 0.3. The dispersion provides a range of 6.0 when taking the difference between the highest mean score (9.5) and the lowest mean score (3.5). Since this is a big range, it can suffer from distortion from these extreme values. In order to eliminate this distortion, the discussion below concentrates on the group dispersion of the mean score in descending order.

Starting with the highest mean scores of 9.5 with two SCMs achieving this mean score. By observation, this mean score of 9.5 can be grouped together with the mean score of 9.3. There seems to be a drop of 0.8 from 9.3 to 8.5. So the second grouping can be formed with the mean score ranging from 8.5 to 8.0. There are four SCMs in this grouping. From 8.0, the next mean score is 7.5 meaning a drop of 0.5. This forms another group ranging from 7.5 to 7.3. There are eight SCMs in this grouping. The next level is the mean score of 7.0 with a drop of 0.3. The mean score of 7.0 and 6.8 forms another grouping with only one SCM each. The following group of dispersion can be formed with the mean score of 6.5 to 6.3 with eight SCMs. Following this group is one SCM with the mean score of 6.0. A drop of 1.0 can be observed for the next mean score of 5.0 which can be grouped together with 4.8 to form the next group. Lastly the mean scores 3.5-3.3 form the last group with two SCMs. Figure 9.3 is shaded to illustrate the above.

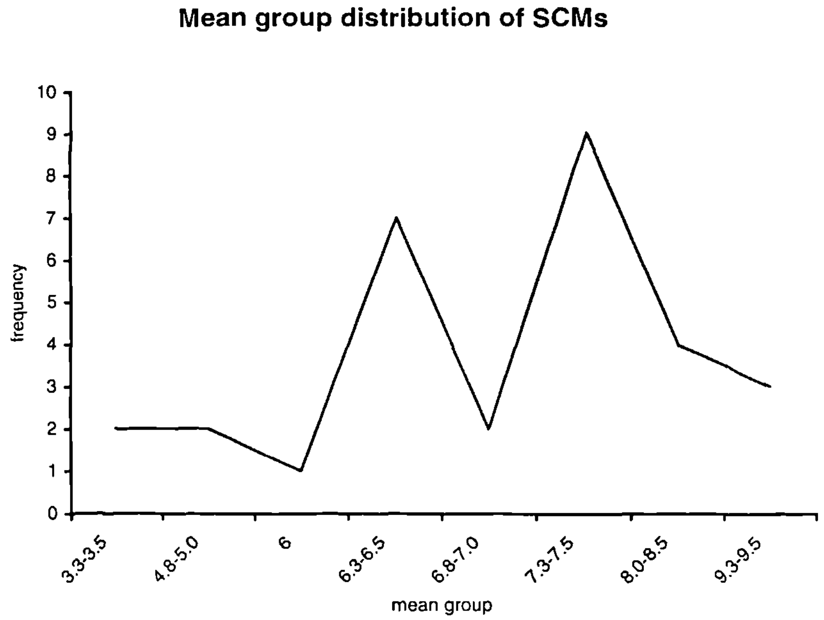


Figure 9.3 – Mean group distributions of SCMs – survey results based on Table 9.7

As can be observed from Figure 9.3, the distribution was skewed to the right. This indicates that higher frequencies of SCMs are within the mean of 6.0 and above. This suggests that most of the SCMs already exist in the company's safety system. The present performance may be due to the ineffectiveness of their implementation.

Standard deviation

The most commonly used method of summarising dispersion is the standard deviation. Here, the standard deviation calculates the average amount of deviation from the mean. The standard deviation reflects the degree to which the values in a distribution differ from the mean.

The SCM – toolbox talk and HSC have the highest standard deviation of 3.4. This means that there is a big dispersion from the mean for these two safety factors. The results suggest that the sites did not strongly agree of the importance of HSC on site safety therefore not all four sites have it implemented on site.

The lowest standard deviation from Table 9.5 is 0.4 for the SCM up-to-date safety policy. Following that 0.4 is also considered small with the SCM – up-to-date safety policy. This small deviation suggests that there was strong agreement with the mean score where all sites implement this important SCM. This SCM is a reflection of management commitment towards safety issues in the organisations.

Variance

Variance is an expression showing the spread or dispersion of the performance score around the mean. SCMs with high standard deviation have a high variance. The SCMs with high variance show strong disagreement from the mean. For example, the highest variance obtained by the SCM - toolbox talks (–5.5 to +3.5). This suggests that Site A with –5.5 variance scored poorly in comparison with the mean for this SCM while Site B obtained +3.5 variance scored higher than the mean. This suggests that these sites scored differently for the SCM - toolbox talks.

Conversely, the lower variance indicates strong agreement between the scores for the SCM in question. For example, the lowest variance is 0 which reflects that there was 100% compliance with the mean. The SCM – procedures for reporting of accidents/incidents clearly shows strong agreement to the mean with two sites achieving 0 variance. This strong agreement reflect that all sites scored highly for this SCM.

Overall, the above discussions reveal the trend of the results obtained among the four sites. Even though the sample is small such comparison has demonstrated the performance scores of each SCM. The results suggest that the two SCMs – HSC and toolbox talks do not appear to be implemented effectively on the test sites. Besides ineffective implementation, the low performance score may be affected by misinterpreting the questions by the respondents. This setback can be overcome by carrying out an evaluation in any future field tests. Whatever the reasons may be, SPMT allowed management to carry out analysis of the answers obtained from the respondents and thus allowed management to plan remedial actions targeting the right category of respondents and the right SCMs.

9.5.2 Comparison within the same company with two sites

Site C and Site D are from the same company with different locations. Both sites are under the same safety director. The aim of this analysis was to show how a single measurement tool like SPMT was able to help organisations to monitor safety performance of its various projects at different locations. The following discussions compare both sites safety performance.

SPMT Index

Table 9.4 shows that Site C performed better than Site D. Site C's SPMT Index score was 74% while Site D scored 64%. It is interesting how both sites differ in the SPMT Index even though they both received the same safety emphasis from regional management. Looking at the SCMs will help to understand further the reasons for this difference.

SCMs performance

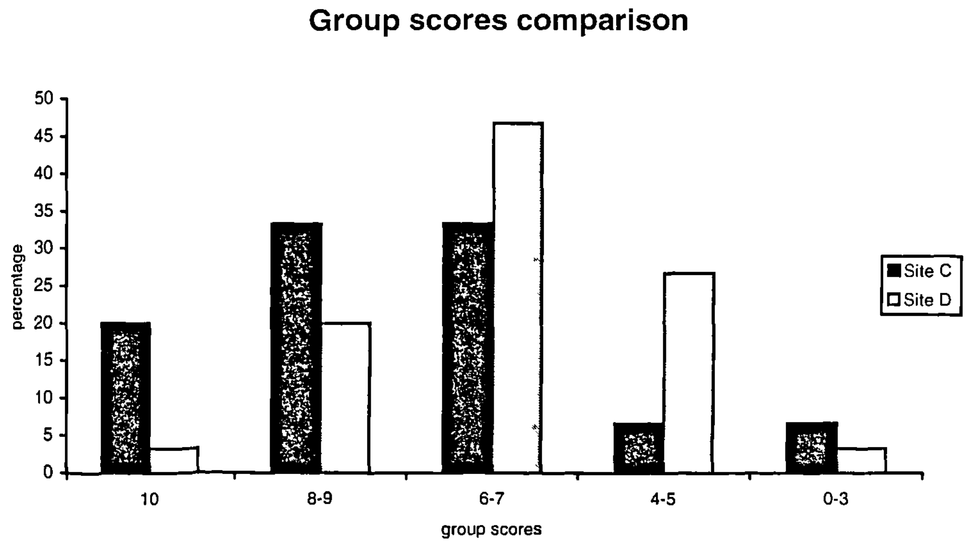


Figure 9.4 – SCMs group performance scores comparison for Site C and Site D – survey results

Figure 9.4 shows the performance score groupings for the SCMs. Site C has 87% of its SCMs in the group score category of 6 and above while Site D only obtained 70% of its SCMs in this grouping. This indicates that 30% of the SCMs in Site D are within the score group of 5 and below. This suggests that Site D have lower effective implementation of safety system in comparison to Site C. On both sites, the suggestion system SCM obtained a poor score. This may indicate that the company does not have an effective suggestion system. Highlighting the weak SCMs will help management to improve the sites performance.

Nevertheless, this analysis helped the management ponder on a few issues. If the management has a generic policy on safety that applies to all sites, then the difference in performance may raise a few questions such as are the sites applying the policy in its original context or are some modifications done or allowed? If the policy is applied in the same context, then this comparison may suggest that Site C performed more safely than Site D. If some form of modification was allowed then the results had highlighted this modification. In conclusion, periodic assessment will help management to make a better comparison. The company was unable to participate in the follow-up assessment in the time of writing this thesis.

9.5.3 Comparison within the same sites with two site tests

Two sites (Site A and Site B) agreed to carry out another test. Prior to the second test, a separate discussion was carried out with the management of both companies to review the results of test 1. Both companies agreed for another test in order to improve its safety performance. Both sites had expected a higher result from the first testing. The following discussions explained the results of both tests for two sites.

Site A

SPMT Index

The results of both tests are as follows:

Testing	Date of testing	SPMT Index	Standard deviation
Test 1	16/02/00	70%	2.50
Test 2	05/05/00	74%	2.48

Overall, test 2 shows an improvement in comparison with test 1 (Figure 9.5). Test 1 can be used as a benchmark for future testing. The standard deviation also is lower in testing 2. To understand how the index has improved, it is best to analyse the SCMs performance. Appendix 9.2 shows the detail results of test 2 for Site A.

SCM performance

Figure 9.6 illustrates the comparison of test 1 and test 2 for Site A. Both tests have an equal 70% of the SCMs in the group score of 6 and above. There has been an increase of SCMs performance towards the category 'excellence'. On the other hand, the number of SCMs in the 'unacceptable' group score had remained unchanged but with different SCMs. The initial SCMs toolbox talks and HSC which were grouped 'unacceptable' in test 1 had seen some changes. The HSC SCM remained unchanged indicating that the management had not decided to form the Health and safety Committee on site. Conversely, SCM – toolbox talks had seen improvement from the score of 1 to the score of 6. This improvement clearly demonstrates management commitment to improve the effectiveness of the existing toolbox talks.

	Carrying out safety audit	Up-to-date safety document	Pre-tender risk assessment	System for reporting acc/inc	System for reporting near miss	Safety policy	Meeting with supervisor	Meeting with SC	Choosing competent SC	HSEComm	Full time SO	Induction training	Planned inspection	Tool-box talk	Construction risk analysis	Method statement	Machine and tools in safe operation	Work permit	Good housekeeping	MSHDS	Emergency response system	Suggestion system	Communication	Safety promotion	Training provided	Safe behaviour exist	Safe working environment	Proper health care	Motivate personnel	Recruiting the right people
	86	70	80	247	160	130	160	160	50	0	120	760	140	60	70	60	20	50	120	40	50	60	120	50	160	450	180	60	160	40
10	166	70	80	329	284	150	170	170	60	130	140	930	240	90	80	70	20	80	130	70	100	240	120	100	320	480	240	100	160	40
9	150	63	72	296	256	135	153	153	54	117	126	837	216	81	72	63	18	72	117	63	90	216	108	90	288	432	216	90	144	36
8	133	56	64	263	227	120	136	136	48	104	112	744	192	72	64	56	16	64	104	56	80	192	96	80	256	384	192	80	128	32
7	116	49	56	230	199	105	119	119	42	91	98	651	168	63	56	49	14	56	91	49	70	168	84	70	224	336	168	70	112	28
6	100	42	48	197	170	90	102	102	36	78	84	558	144	54	48	42	12	48	78	42	60	144	72	60	192	288	144	60	96	24
5	83	35	40	164	142	75	85	85	30	65	70	465	120	45	40	35	10	40	65	35	50	120	60	50	160	240	120	50	80	20
4	66	28	32	132	114	60	68	68	24	52	56	372	96	36	32	28	8	32	52	28	40	96	48	40	128	192	96	40	64	16
3	50	21	24	99	85	45	51	51	18	39	42	279	72	27	24	21	6	24	39	21	30	72	36	30	96	144	72	30	48	12
2	33	14	16	66	57	30	34	34	12	26	28	186	48	18	16	14	4	16	26	14	20	48	24	20	64	96	48	20	32	8
1	17	7	8	33	28	15	17	17	6	13	14	93	24	9	8	7	2	8	13	7	10	24	12	10	32	48	24	10	16	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Score	5	10	10	7	5	8	9	9	8	0	8	8	5	6	8	8	10	10	9	5	5	3	10	5	5	9	7	6	10	10
Weight	62	78	76	74	62	78	72	68	72	56	70	70	70	68	76	94	84	78	68	64	82	64	74	58	80	86	88	74	66	68
Total	310	780	760	518	310	624	648	612	576	0	560	560	350	408	608	752	840	780	612	320	410	192	740	290	400	774	616	444	660	680

Performance score

STANDARD DEVIATION
2.48

SPMT INDEX
74%

90-100%	Excellent
70-89%	Very good
50-69%	Good - need to improve
30-49%	Moderate/poor - need to improve harder
0-29%	Unacceptable - need to take urgent actions

Figure 9.5 - SPMT Index for Site A (test 2)

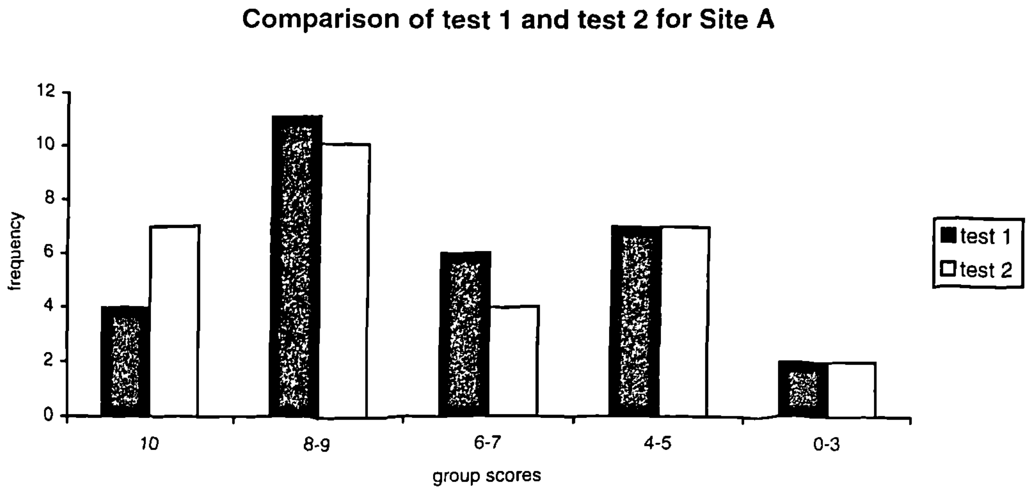


Figure 9.6 – Comparisons of SCMs performance score test 1 and test 2 for Site A – survey results

Looking at the questions of toolbox talks questions below in test 2 will demonstrate the changes in comparison with the response in test 1.

Questions		test 1	test 2
Supervisors questions			
7a	Do you conduct toolbox talks for the following? (tick each box that applies)		
	• daily for pre-task	√	√
	• weekly for general safety	×	×
7b	Do the talks focus on gang's particular work?	×	√
7c	Do the talk last no more than 10 minutes?	×	×
7d	Do you record all toolbox talks?	×	√
7e	Do you review tasks, method statements and work permits with workers during toolbox talks?	√	√
7f	Do you carry out risk assessment before work commences?	×	√
7g	Do you initiate actions on all sub-standard situations?	×	√
Document checks questions			
10	Record of toolbox talks	×	√

The supervisors had implemented seven out of nine indicators for this SCM compare with only two indicators from test 1. The supervisors had even recorded all the toolbox talks carried out on site. This positive reaction from the management had improved the overall performance of this SCM.

Table 9.6 highlights the changes in SCM performance after test 2 based on a group score of 5 and below classified 'unacceptable' and 'moderate/poor'. There were nine SCMs in this group. Overall, four SCMs had remained unchanged, one SCM had declined its safety performance while four SCMs had improved. The best improvement was for the toolbox talks SCM which had improved from 'unacceptable' to 'good'. The other SCM that improved well was the machinery SCM which improved from 'moderate/poor' to 'excellent'. The overall SCMs performance in both test 1 and test 2 can be observed from Table 9.7.

Table 9.6 – Changes of SCMs performance for test 1 and test 2 – survey results

Weak SCMs	Test 1	Test 2	Change
Toolbox talk	1	6	+5
HSC	0	0	0
Suggestion system	4	3	-1
Machinery and equipment in working condition	5	10	+5
Procedure for reporting accidents/incidents	5	7	+2
MSHDS	5	5	0
Safety audit	5	5	0
Safe working environment	5	7	+2
Training	5	5	0

Table 9.7 – SCMs performance scores for Site A (test 1 & 2) – survey results

Safety control measures	Site A test 1	Site A test 2	Change
Safety audit	5	5	0
Up-to-date safety documentation	10	10	0
Pre-tender risk assessment	10	10	0
Procedures for reporting accidents/incidents	5	7	2
Procedures for reporting near misses	6	5	1
Up-to-date safety policy	8	8	0
Safety meeting with supervisors	8	9	1
Safety meeting with specialist-contractors	7	9	2
Selection of specialist-contractors based on safety issues	8	8	0
Health & Safety Committee (HSC)	0	0	0
Safety officer	6	8	2
Induction training	6	8	2
Site inspection	8	5	3
Tool-box talks	1	6	5
Construction risk analysis	8	8	0
Method statements	8	8	0
Permit-to-work system	10	10	0
Machinery & equipment in safe working condition	5	10	5
Good housekeeping	8	9	1
Material Safety Health Data Sheet	5	5	0
Emergency response system	8	5	-3
Safety suggestions	4	3	-1
Communication	9	10	1
Safety promotions	6	5	-1
Training	5	5	0
Safe behaviour	6	9	3
Safe working environment	5	7	2
Effective health care	8	6	2
Motivation to safe behaviour	8	10	2
Recruiting the right people	10	10	0

Note:
Spearman's correlation coefficient between test 1 and test 2 is 0.975 with a significance value of 0%. This means that there is a strong agreement in the ranking of the SCMs between the two tests.

Site B

SPMT Index

The results of both testing are as follows:

Testing	Date of testing	SPMT Index	Standard deviation
Test 1	14/02/00	74%	2.50
Test 2	12/06/00	76%	1.85

Overall, test 2 shows an improvement in comparison with test 1 (Figure 9.7). Test 1 can be used as a benchmark for future testing. The standard deviation also is lower in test 2. To understand how the index has improved, it is best to analyse the SCMs performance.

Performance score	Carrying out safety audit	Up-to-date safety document	Pre-tender risk assessment	System for reporting acc/inc	System for reporting near miss	Safety policy	Meeting with supervisor	Meeting with SC	Choosing competent SC	HSECOmm
	121	50	60	221	130	80	140	110	40	90
10	166	70	80	329	284	150	170	170	60	130
9	150	63	72	296	256	135	153	153	54	117
8	133	56	64	263	227	120	136	136	48	104
7	116	49	56	230	199	105	119	119	42	91
6	100	42	48	197	170	90	102	102	36	78
5	83	35	40	164	142	75	85	85	30	65
4	66	28	32	132	114	60	68	68	24	52
3	50	21	24	99	85	45	51	51	18	39
2	33	14	16	66	57	30	34	34	12	26
1	17	7	8	33	28	15	17	17	6	13
0	0	0	0	0	0	0	0	0	0	0
Score	7	7	7	6	4	5	8	7	6	6
Weight	62	78	76	74	62	78	72	68	72	56
Total	434	546	532	444	248	390	576	476	432	336

Performance score	Full time SO	Induction training	Planned inspection	Tool-box talk	Construction risk analysis	Method statement	Machine and tools in safe operation	Work permit	Good housekeeping	MSHDS
	140	900	120	70	60	70	20	80	100	50
10	140	930	240	90	80	70	20	80	130	70
9	126	837	216	81	72	63	18	72	117	63
8	112	744	192	72	64	56	16	64	104	56
7	98	651	168	63	56	49	14	56	91	49
6	84	558	144	54	48	42	12	48	78	42
5	70	465	120	45	40	35	10	40	65	35
4	56	372	96	36	32	28	8	32	52	28
3	42	279	72	27	24	21	6	24	39	21
2	28	186	48	18	16	14	4	16	26	14
1	14	93	24	9	8	7	2	8	13	7
0	0	0	0	0	0	0	0	0	0	0
Score	10	9	5	7	7	10	10	10	7	7
Weight	70	70	70	68	76	94	84	78	68	64
Total	700	630	350	476	532	940	840	780	476	448

Performance score	Emergency response system	Suggestion system	Communication	Safety promotion	Training provided	Safe behaviour exist	Safe working environment	Proper health care	Motivate personnel	Recruiting the right people
	100	150	120	100	170	410	180	90	110	40
10	100	240	120	100	320	480	240	100	160	40
9	90	216	108	90	288	432	216	90	144	36
8	80	192	96	80	256	384	192	80	128	32
7	70	168	84	70	224	336	168	70	112	28
6	60	144	72	60	192	288	144	60	96	24
5	50	120	60	50	160	240	120	50	80	20
4	40	96	48	40	128	192	96	40	64	16
3	30	72	36	30	96	144	72	30	48	12
2	20	48	24	20	64	96	48	20	32	8
1	10	24	12	10	32	48	24	10	16	4
0	0	0	0	0	0	0	0	0	0	0
Score	10	6	10	10	5	8	7	9	6	10
Weight	82	64	74	58	80	86	88	74	66	68
Total	820	384	740	580	400	688	616	666	396	680

STANDARD DEVIATION
1.85

SPMT INDEX
76%

90-100%	Excellent
70-89%	Very good
50-69%	Good - need to improve
30-49%	Moderate/poor - need to improve harder
0-29%	Unacceptable - need to take urgent actions

Figure 9.7 - SPMT Index for Site B (test 2)

SCM performance

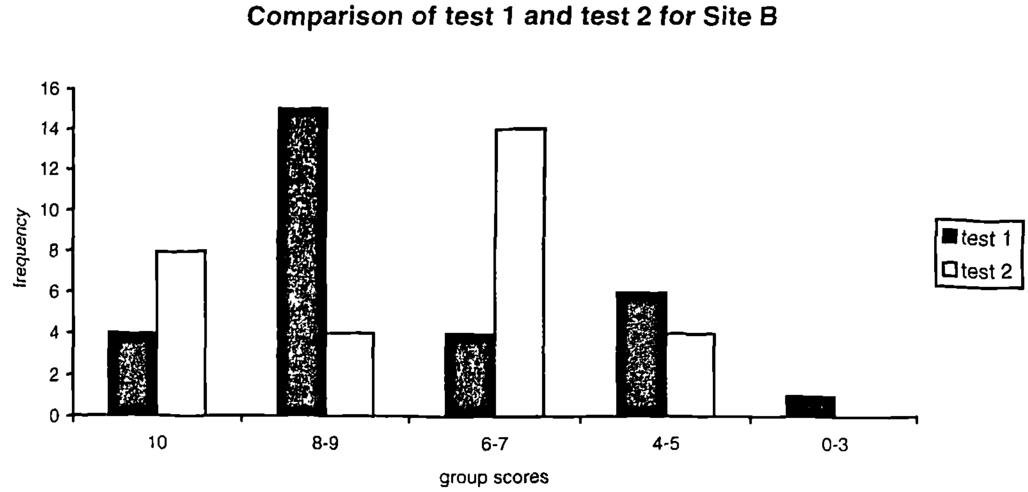


Figure 9.8 – Comparison of SCMs performance score test 1 and test 2 for Site B – survey results

Figure 9.8 illustrates the comparison of test 1 and test 2 for Site B. Test 2 has 87% of SCMs under the group score of 6 and above while test 1 have 77%. There was an increase if 50% in the number of SCMs in the 'excellent' group score in test 2. This is a good improvement for the project. Besides having more 'excellent' group scores, test 2 does not have any SCM in the 'unacceptable' category. The pre-tender risk assessment SCM improved from the category of 'unacceptable' to 'good'. This is a positive improvement to the safety performance of the project. Table 9.8 highlights the changes of SCMs performance after carrying out test 2 based on the group score of 5 and below.

Table 9.8 – Changes of SCMs performance for test 1 and test 2 – survey results

Weak SCMs	Test 1	Test 2	Change
Pre-tender risk assessment	3	7	+4
Safety documents	4	7	+3
Meetings with specialist-contractors	4	7	+3
Machinery and equipment in safe working condition	5	10	+5
Training	4	5	+1
Site inspection	4	5	+1
Procedures for reporting near miss	5	4	-1

From Table 9.8, the performance in all six SCMs improved except for the procedure for reporting near misses SCM. The machinery and equipment SCM improved greatly. The overall SCMs performance in both test 1 and test 2 can be observed from Table 9.9.

Table 9.9 – SCMs performance scores for Site B (test 1 & 2)

Safety control measures	**Site A**	**Site A**	**Change**
	Testing 1	**Testing 2**	
Safety audit	5	5	0
Up-to-date safety documentation	10	10	0
Pre-tender risk assessment	10	10	0
Procedures for reporting accidents/incidents	5	7	-2
Procedures for reporting near misses	6	5	-1
Up-to-date safety policy	8	8	0
Safety meeting with supervisors	8	9	1
Safety meeting with specialist-contractors	7	9	2
Selection of specialist-contractors based on safety issues	8	8	0
Health & Safety Committee (HSC)	0	0	0
Safety officer	6	8	2
Induction training	6	8	2
Site inspection	8	5	3
Tool-box talks	1	6	5
Construction risk analysis	8	8	0
Method statements	8	8	0
Permit-to-work system	10	10	0
Machinery & equipment in safe working condition	5	10	5
Good housekeeping	8	9	-1
Material Safety Health Data Sheet	5	5	0
Emergency response system	8	5	-3
Safety suggestions	4	3	-1
Communication	9	10	1
Safety promotions	6	5	-1
Training	5	5	0
Safe behaviour	6	9	-3
Safe working environment	5	7	-2
Effective health care	8	6	-2
Motivation to safe behaviour	8	10	2
Recruiting the right people	10	10	0

9.5.4 Comparison with reactive data

A comparison was carried out to collate the reactive measures with the SPMT Indices. The data are as in Table 9.10

Table 9.10 – Reactive data for Site A, Site B, Site C and Site D

Information	Site A		Site B		Site C	Site D
	test 1	**test2**	**test1**	**test2**	**test1**	**test1**
Progress of project	50%	65%	35%	50%	95%	50%
Total workforce (no)	38	38	385	520	300	300
Total man-hour	45600	18240	450000	695000	500000	200000
Reactive data (no)						
• fatality	0	0	0	0	1	0
• lost days cases	0	0	0	0	7	2
• doctor's cases	0	0	17	22	7	10
• first-aid cases	4	0	47	71	40	40
• property damage	0	0	6	10	0	0
• environmental damage	0	0	2	3	0	0
SPMT Index	70%	74%	74%	76%	75%	64%

When employing less than 1000 employees a multiplier of 100 is occasionally used. Only by using the same multiplier can comparison be made. The formuli used are based on the recommendation by Labour Office (Ridley 1994). Ridley stated that the calculation of incident rates can include other incidents besides injury accidents that represent losses for an organisation. Examples of these types of incident include: damage accidents, sickness absence, machine or plant failures, defective products or product faults. For this research, the incidence rate was calculated by adding the number cases in the following category:

- doctor's cases;
- first-aid cases;
- property damage; and
- environmental damage.

The fatality and lost days cases was not used due too small data. The incidence rate is calculated as follows:

Incidence rate

$$= \frac{\text{total number of accidents}}{\text{number of persons employed}} \times 1000$$

Results are as follows:

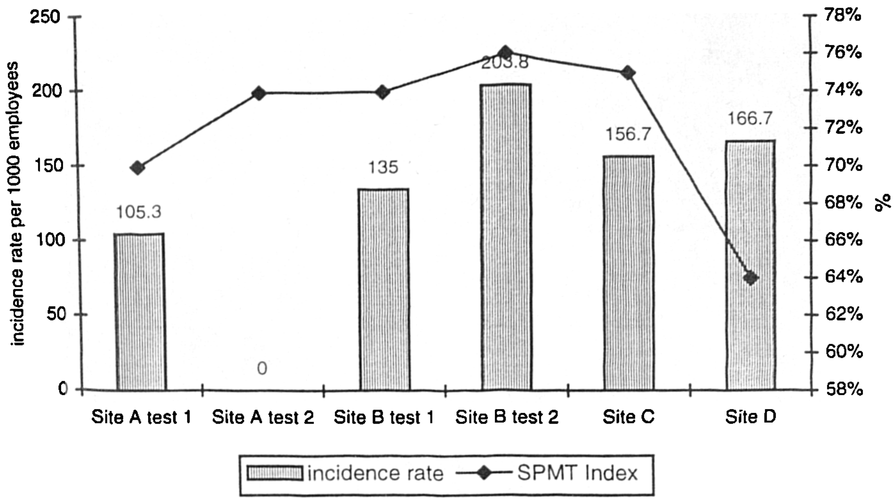


Figure 9.9 – Comparison between SPMT Index with incidence rate

Even though the sample was too small to do derive to any conclusions, nevertheless a comparison with the reactive data was carried out to draw a trend. From Figure 9.9, the following comments can be made:

1. Site A has the lowest incidence rate. This may be due to the smaller workforce on site, easier to control, and less hazardous project undertaken. On the other hand, it may be due to under reporting.
2. The high incidence rate for Site B may be due to higher man-hour on the project and better level of reporting accident/incidence.
3. There may be different definitions of an incident being used by each site. Each organisation may adopt different degrees of severity of injury for classification as accident/incident especially for the less severe case.
4. The employees and the nature of their work vary from building residential homes to building a petrochemical plant. Therefore it will be very difficult to compare the incidence rate as the hazards are so different.
5. The sample is too small to make significant comparison.

9.5.5 Summary of implementation of SPMT

SPMT was implemented on on-going projects. The conclusions are as follows:

Ease of use

SPMT is a self-explanatory tool that can be implemented without much fuss following a two-hour briefing with site management by the researcher. All four sites successfully implemented SPMT without further intervention from the researcher. The language used was simple and easy to understand. The comments made by the management either on paper or verbally demonstrated the simplicity of SPMT. The management from Site A and Site B have given a written comment about SPMT in general (Appendix 9.3). The project manager of Site C and Site D was not able to give any written comment due to his resignation from the company.

Improvement tool

SPMT also demonstrated on all the case study sites its ability to identify the level of performance of each SCM. The identification of the weaker SCMs had enabled management to focus on improving their performance. Site A and Site B both identified the weaker SCMs and planned remedial actions accordingly. In order to measure the effectiveness of the actions taken, another assessment was carried out. The result demonstrated an improvement on the identified weak SCMs. SPMT is not only a measurement tool, but is also able to identify and improve the SCMs on the project.

Reliability

Any measurement tool must demonstrate its reliability, meaning the degree of consistency in producing the same results for two measures of same thing. Since the samples for this research are small, reliability across time cannot be demonstrated. The reliability test that can be carried out is that within the tool. This mean looking at the uniformity the responses to questions asked. The example shown in Table 9.11 are the responses gathered from the operative's level from Site B, C and D. Site A has been excluded for this comparison as they only returned responses from one site operatives. In all, each operative has 94 responses to make. There were five operatives answering on each of the four site applications, giving a total number of 376 data sets.

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
1a	Do you participate in safety audits? *(This is where the safety procedures are checked periodically throughout the project)*	X√√XX	60%	X√XX√	60%	XX√X√	60%	X√√XX	60%
1b	If yes, did you receive any pre-audit training?	XXXXX	100%	XXXXX	100%	XXXXX	100%	XXXXX	100%
2a	Do you know about the project's system of reporting of accidents/incidents?	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√√√	100%
2b	If yes, when were you told about it? *(tick only one box)*								
	• Anytime before or during the induction course	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√√√	100%
	• Only after an accident/incident had occurred								
2c	After an accident had occurred, did you receive feedback about the analysis of accident/incident investigation from management?	√√√√√	100%	√√X√√	80%	XX√XX	80%	X√XXX	80%
2d	When did you receive the feedback of accidents/incidents investigation analyses? *(tick only one box)*								
	• Daily inspections	XXXXX	100%	XXXXX	100%	XX√XX	80%	XXXXX	100%
	• Weekly site meetings	XX√XX	80%	XXXXX	100%	XXXXX	100%	X√XXX	80%
	• Tool-box talks	√√X√√	60%	√XX√√	60%	XXXXX	100%	XXXXX	100%
	• No specific time	XXXXX	100%	X√XXX	80%	XXXXX	100%	XXXXX	100%
3a	Do you know about the project's system for reporting near misses?	√√√√√	100%	√√√√√	100%	XX√X√	60%	XX√XX	60%
3b	If yes, when were you informed? *(tick only one box)*								
	• Anytime before or during the induction course	√√√√√	100%	√√√√√	100%			XX√XX	80%
	• Only after the a near miss had occurred					XX√X√	60%		
3c	After a near miss had occurred, did you receive feedback about the analyses of investigation from management?	√√√√√	100%	√√√√√	100%	XXXXX	100%	XX√XX	80%

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
3d	If yes, when did you receive the feedback of near miss investigation analyses? *(tick one box only)*								
	• Daily inspections	√XXXX	80%	XX√XX	80%	XXXXX	100%	XXXXX	100%
	• Weekly site meetings	X√XXX	80%	XXXXX	100%	XXXXX	100%	XX√XX	80%
	• Tool-box talks	XX√√√	60%	√XX√√	60%	XXXXX	100%	XXXXX	100%
	• No specific time	XXXXX	100%	X√XXX	80%	XXXXX	100%	XXXXX	100%
4a	Did you receive the project's safety policy?	√√√√√	100%	√√√√√	100%	√√√√√	100%	√X√XX	60%
4b	When is the safety policy given to you? *(tick only one box)*								
	• Any time before or during the induction training	√√√√√	100%	√√√√√	100%	√√√√√	100%		
	• After the induction training							√X√XX	60%
5	Is MSHDS (material safety health data sheet) provided for all personnel with specific information on chemicals that the personnel will come in contact with?	X√√√X	60%	X√√X√	60%	√√√√√	100%	√X√XX	60%
6a	Are you informed of the necessary action to be taken during an emergency?	√√√√√	100%	X√√X√	60%	X√√√√	80%	XX√XX	80%
6b	Is training required for all personnel who involve to hazardous substances?	X√√√√	80%	X√√√X	60%	X√√√√	80%	X√√XX	60%
6c	Did you participate in drills at least once during the project?	X√√√√	80%	√√X√X	60%	XX√√X	60%	XXXXX	100%
7a	Did you attend induction training on your first day on site?	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√X√√	60%
7a	Does the induction training cover the following? *(tick each box that applies)*								
	• safety rules	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√√√	100%

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
	• safety policy	√√√√√	100%	√√√√√	100%	√√√√√	100%	√X√X√	60%
	• safety regulations	√√√√√	100%	√√√√√	100%	X√√√√	80%	√√√XX	60%
	• personnel rights and responsibilities	√√X√√	80%	X√√√√	80%	X√√√√	80%	XX√X√	60%
	• overview of company procedures	√X√√√	80%	X√X√√	60%	X√√√X	60%	XX√√√	60%
	• site management hierarchy	√√√√X	80%	XXX√X	80%	XX√X√	60%	XX√√X	60%
	• introduction of personnel to their supervisors	√XXX√	60%	X√√XX	60%	X√√X√	60%	XX√√√	60%
	• notification of emergency plan	√√√√√	100%	√√√√√	100%	X√√√√	80%	XX√XX	80%
	• location of medical and emergency aid	√√√√√	100%	√√√X√	80%	XX√√√	60%	XX√√√	60%
	• site layout	√√√√√	100%	X√√X√	60%	XX√√√	60%	√X√XX	60%
	• housekeeping arrangements	√√XXX	60%	√√√X√	80%	X√√√√	80%	√X√XX	60%
	• permit-to work systems and method statements	√√√√√	100%	√√√√√	100%	√√√√√	100%	XX√√√	60%
	• reporting system for accidents/incidents	√√√√√	100%	√√√√√	100%	√√√√√	100%	√X√√√	80%
	• reporting system for near misses	√√√√√	100%	√√√√√	100%	XX√X√	60%	XX√XX	80%
	• security system, issue of passes and permits	√√√√√	100%	√√√√√	100%	X√√√√	80%	XX√√√	60%
7c	Did you receive some proof of attendance after attending the induction training?	√√√√√	100%	√√√√√	100%	√√√√√	100%	XXX√√	60%
7d	Did the induction training last for not more than one working day?	√√√√X	80%	√X√√√	80%	√XXX√	60%	XX√√√	60%
7e	Did the site management conduct a tour of the work place noting exit, dangers etc?	√XX√√	60%	X√√√X	60%	XX√XX	80%	XXX√X	80%
7f	Did the site management use written materials and visual aids to conduct induction training?	√√√√√	100%	√√√√√	100%	√√√√√	100%	XX√√√	60%
7g	Did you receive proper advice regarding PPE (personal protective equipment), during induction e.g. instruction on how to wear it or how to look after it, etc.?	√√√√√	100%	√√√√√	100%	√√√√X	80%	√√√√√	100%

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
7h	Did you receive a safety handbook which is appropriate to you at the end of the induction training?	√√√√√	100%	√√√√√	100%	XX√XX	80%	XXXXX	100%
7i	Was an evaluation carried out at the end of the course either verbal or written?	√XX√√	60%	√√√X√	80%	XX√XX	80%	XXXXX	100%
8a	Do you know about the informal system for making recommendations, safety suggestions or improvements e.g. verbal or union leaders?	√XX√√	60%	X√√√√	80%	XX√√X	60%	XX√X√	60%
8b	Do you know about the formal system where personnel are encourage to make safety suggestions, recommendations or improvements such as: *(tick each one that applies)*	XXX√X	80%	√X√√√	80%	X√√√√	80%	XXXXX	100%
	• suggestion box	XXXXX	100%	XX√√√	60%	X√√X√	60%	XXXXX	100%
	• suggestion forms	XXXXX	100%	√X√√√	80%	XXXXX	100%	XXXXX	100%
	• site canteen	XXXX√	80%	√XXXX	80%	XXX√X	80%	XXXXX	100%
8c	Has the company ever announced any suggestions that had been accepted and who suggested them?	XXXXX	100%	XXXXX	100%	XXXXX	100%	XXXXX	100%
9a	Does a clear chain of command: exist among HQ management, site management, supervisors, specialist-contractors and operatives?	√√XX√	60%	√√X√√	60%	√√√√√	100%	√√√√√	100%
9b	Do you receive work instructions from management during meetings e.g. daily meetings or weekly meetings?	XX√√√	60%	√√√√X	80%	XX√√√	60%	XX√√√	60%
10a	Do you receive any medical facilities on this project e.g. first aid?	√√√√√	100%	√√√√√	100%	√X√√√	80%	XX√√√	60%
10b	Did you complete a pre-employment medical questionnaire?	X√√√√	80%	√√√X√	80%	X√XXX	80%	√X√XX	60%
11a	Do you work in a safe working environment?	√√√√√	100%	√√√√√	100%	√√√√√	100%	X√√√√	80%

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
11b	There is a continuous message that no job is so important that safety is overlooked?	√√√√√	100%	√√√√√	100%	XX√X√	60%	X√√X√	60%
11c	Do you know the company safety rules and procedures?	√√√√√	100%	√√√√√	100%	√√√√√	100%	√X√XX	60%
11d	How often do you comply with the rules and procedures? *(tick only one box)*								
	• All the times	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√√√	100%
	• Sometimes								
	• Never								
11e	How often do you follow the directions given by management or supervisors? *(tick only one box)*								
	• All the times	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√√√	100%
	• Sometimes								
	• Never								
11f	Regarding PPE (personal protective equipment), do you...... *(tick each box that applies)*								
	• wear because you are concerned about safety?	√√√√√	100%	√√√√√	100%	√√√√√	100%	√X√√√	60%
	• wear it voluntarily?	√√XXX	60%	XX√X√	60%	√XX√√	60%	XX√XX	80%
	• use only steel-toed shoes or safety boots?	X√√√√	80%	√X√√√	80%	√√√√√	100%	X√√XX	60%
	• ensure safety shields and guards are in place and secured prior of commencement of equipment operations?	√XXX√	60%	√X√√√	80%	√√√√√	100%	X√√XX	60%
	• use the right PPE whenever appropriate and required?	√√√√√	100%	√√√√√	100%	√√√√√	100%	X√√XX	60%
	• Always get PPE that suits you in terms of size & height?	√XX√√	60%	XX√√√	60%	√√√√√	100%	X√√XX	60%
	• receive training on how to use it?	√XX√√	60%	√X√X√	60%	√√X√√	60%	X√XXX	80%
	• return used or damaged PPE and receive a reissue	√XXXX	80%	√√√√√	100%	X√X√√	60%	X√√XX	60%

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
11g	Regarding tool, machinery and equipment, do you………… *(tick each box that applies)*								
	• know where safety equipment is and how to use it correctly?	√√√√√	100%	√√√√√	100%	√√√√X	80%	X√√XX	60%
	• only handle equipment, tool and machinery when you are trained?	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√XX	60%
	• store and maintain all equipment – ensure they are clean, safe in operation?	√√√√√	100%	√√√√√	100%	X√√√√	80%	X√√XX	60%
	• return the equipment to the sores if condition is unsafe?	√√√√√	100%	√√√√√	100%	√√X√√	80%	X√√XX	60%
11h	On this project, have you taken any of the following actions before? *(tick each box that applies)*								
	• reported any substandard working condition or suspected of being unsafe to the supervisor	X√√√X	60%	√√XX√	60%	√√√√√	100%	X√√XX	60%
	• reported any near miss or incident/accident to supervisors, no matter how slight it seems?	X√√√√	80%	X√√√√	80%	√X√XX	60%	X√√XX	60%
	• stop work if you felt it was unsafe to continue?	X√√XX	60%	X√√X√	60%	√√√√√	100%	√√√XX	60%
12a	Are the goals set by management attainable?	√√XXX	60%	√√XX√	60%	√√√√√	100%	XX√√√	60%
12b	Do the management encourage active participation of personnel in decision making?	√√XXX		X√X√X					
12c	Are you rewarded for good safety performance?	√XXXX	80%	XX√X√	60%	√XXXX	80%	XXXXX	100%
12d	Does the existing appraisal system recognise good safety performance?	XXXXX	100%	X√√√X	60%	XX√√X	60%	X√XXX	80%
13	On this project, have you attended any of the following training programmes? *(tick each box that applies)*								
	• Induction	√√√√√	100%	√√√√√	100%	√√√√√	100%	√√√√√	100%
	• Pre-audit training	XXXXX	100%	XXXXX	100%	XX√XX	80%	X√XX√	60%

Table 9.11 – Responses from four applications (site B1, B2, C and D) by operatives on SPMT questions

		Site B1		Site B2		Site C		Site D	
	Indicators	Response	Agreement	Response	Agreement	Response	Agreement	Response	Agreement
	• Training for undertaking reporting of accident/incident and near misses	XXXXX	100%	XX√XX	80%	XX√XX	80%	X√XXX	80%
	• Emergency response system	√√√√√	100%	X√√XX	60%	XX√√X	60%	XXXXX	100%
	• Training for high risks job	X√√√√	80%	X√XXX	80%	XX√√X	60%	X√√XX	60%
	• Training for handling hazardous materials	X√√√√	80%	X√√XX	60%	XX√√X	60%	X√XXX	80%
	• Risk assessment training	XXXX√	80%	√√XXX	60%	XX√X√	60%	X√XXX	80%
14	Does the working environment provide the following? *(tick each box that applies)*								
	• proper guards and support	X√√√√	80%	√√√√√	100%	√√√√√	100%	√√√√√	100%
	• proper illumination	X√√√√	80%	√√√√√	100%	√√√√√	100%	√X√√√	80%
	• proper ventilation	X√√√√	80%	√√XX√	60%	√√√√√	100%	√X√√√	80%
	• work place not congested	X√√√√	80%	√√XX√	60%	√X√√√	80%	√X√√√	80%
	• all tools and equipment in working condition	X√XX√	60%	√√√√√	100%	√√√√√	100%	√√√√√	100%
	• orderly work place	X√XX√	60%	√√XX√	60%	√√√√√	100%	√√√√√	100%
	• proper warning and detection style	X√√√√	80%	√√√X√	80%	XX√√√	60%	√X√√√	80%
	• suitable and sufficient welfare facilities	X√√√√	80%	√√√√√	100%	√√√√√	100%	√X√√√	80%
	•								

From Table 9.11, the following results are obtained:

Applications	Percentage agreement between operatives	Standard deviation
Site B1	85%	0.16
Site B2	83%	0.17
Site C	83%	0.17
Site D	76%	0.17
Overall	82%	0.17

The result shows that Site B1, B2 and C had more than four operatives all answered the questions the same way while Site D just less than four. Overall there was an agreement of 82% between the operatives on each sites.

A breakdown will help to understand the results better. Table 9.12 below shows the number of questions according to their level of agreement.

Table 9.12 – Results of operatives performance scores

Sites	60% agreement (3/5)	80% agreement (4/5)	100% agreement (5/5)	Total number of questions
Site B1	20	24	50	94
Site B2	27	23	44	94
Site C	26	24	44	94
Site D	43	22	29	94
Total	116	93	167	**376**

From the total of 376 data sets, almost 70% achieved an agreement of more than 4/5 which demonstrates the reliability of SPMT questions. To test whether the operatives agreement was likely to be a chance event, the univariate chi-square test was applied. The formula for χ^2 is

$$\chi^2 = \Sigma\frac{(O-E)^2}{E}$$

where *O* represents the observed number of cases and *E* represents the number of cases expected (Bernard 2000). The results are as follows:

Results	Site B1	Site B2	Site C	Site D
Chi-Square (χ^2)	15.340	11.894	11.894	6.468
Df	2	2	2	2
Asymp. Sig.	0.000	0.003	0.003	0.039

Note:
df = degree of freedom
Asym.p Sig= asymption significance

Bernard (2000) suggested that a satisfactory significance level is 0.10 or less. Therefore the agreement of response among the operatives for all four applications were not due to chance. Their agreements simply reflect what is their opinion about the effectiveness of the SCMs.

The reason for the 31% where only 3/5 agreement was achieved may be due:

- discrepancies on the projects, meaning safety was not communicated effectively and efficiently; or
- ambiguity some questions that pose difficulty for the operatives to understand.

9.4 SUMMARY

1. Four sites participated in test 1 and two sites participated in test 2. Two sites are from the same organisations under the same regional manager.

2. The analysis on the four sites results was not intended to compare which sites did better but rather to demonstrate what SPMT is able to do.

3. Overall all four sites performed within the 'good' and 'very good' SPMT Index. This is not surprising seeing that the participants are organisations with a strong emphasis on safety. Most of the management expected an even a higher score.
4. The dispersion of the SCMs performance score was as expected. The highest standard deviation was 3.5 and the lowest was 0.4. This shows a big dispersion from the mean for the Health and Safety Committee (HSC) SCM that obtained the standard deviation 3.3.

5. The highest mean performance score was 9.5 for the method statements and work permits SCMs. This shows that all the four sites agreed on these safety factors. Overall 87% of the SCMs achieved a mean performance score of 6.0 and above. The four SCMs that obtained mean performance score of 5.0 and below are training, procedures for reporting near misses, safety suggestions and HSC.

6. The results of test 1 for Site C and Site D were compared. These two sites had the same principal contractor and the same regional manager. The analysis will be able to help management to focus on the weak SCMs on each sites and study why some SCMs perform differently on these two sites. For example, Site C scored 0 for HSC and Site D scored 5. This may create some confusion as to whether HSC's exist under this management or they do not understand the questions. Another example is for the selection of specialist-contractors. Site C had agreed on this SCM 100% while Site D only obtained a performance score of 6. This may suggest lack of communication between management and the projects.

7. SPMT is intended to be applied periodically on the same site. Site A and Site B agreed to participate with a second follow-up test. Periodic testing will enable management to identify trends and the weak SCMs that are constantly performing low or respondent categories that tend to respond negatively.

8. Overall, both sites improved on the second test. SPMT had helped management to identify weak safety factors and management had taken steps to improve performance.

9. The SPMT trials had demonstrated the difficulty of comparing the SPMT Index to reactive data due to different interpretations for different companies particularly for the non-RIDDOR data. Reactive data is not a reliable guide as there is no consistency with the data from one site to another. On the contrary it was easier to do comparisons of SPMT indices because all the trial sites were being compared with the same SCMs. This clearly proves that the industry will benefit from having a single generic safety performance measurement tool.

10. Management had expressed their opinion about SPMT in Appendix 9.3. In conclusion, SPMT had provided the management a safety assessment. The results had helped them to focus on improvement of safety on sites.

11. Even though SPMT was answered using the hardcopy version, from discussions during the trials the future potential of SPMT as an information communication technology (ICT) tool is very promising. The design of SPMT as a hand held computer would see the benefit of this tool for future use on any size of project.

12. The trials demonstrated that SPMT is easy to use. The sites successfully used the tool on its own after the initial briefing with management without further intervention from the researcher. Beside the ease of use, SPMT also shows its ability an improvement tool. Both Site A and Site B had identified the weak SCMs in the first test and planned remedial actions. The follow-up tests demonstrated improvements on the identified weak SCMs.

13. The measure of reliability was carried within the tool. This was done by comparing the operatives performance score on each site for each question. All together there were 94 responses for each operatives to make. In all four sites, there were 376 data sets. Overall, there was an agreement of 82% between the operatives on each sites.

CHAPTER 10

SUMMARY AND CONCLUSIONS

10.1 INTRODUCTION

This chapter presents the conclusions of the thesis, demonstrates the contribution to the body of knowledge and lastly makes recommendations for further work.

The aim of this research was to develop a standard tool to measure not only the level of safety but to evaluate the effectiveness of safety performance, provide continuous information concerning changes in the safety state and enable identification of potential causes of future loss.

The aim was realised through the achievement of the following three objectives:

- identification of the thirty important proactive safety control measures (SCMs) and indicators of safety performance for construction sites;
- development a safety performance measurement tool (SPMT); and
- validation of SPMT through implementation on case study sites.

10.1.1 Identify The Important Proactive Safety Control Measures (SCMs) And Indicators

The following steps were taken to identify the important proactive safety control measures (SCMs) and indicators of safety performance for construction sites:

Literature review

A comprehensive literature review revealed that various safety performance tools existed, but there was no overall approach that could be adopted for any construction site. More specifically, this review established:

a) existing scenario of safety performance assessment in the construction industry (Section 3.2);
b) a list of accident causation theories (Section 2.2);
c) reactive and proactive measures of safety (Figure 3.6 and Figure 3.7);
d) a list of initial factors and sub-factors that were being measured in existing systems (Appendix 5.1);
e) methods of analysing data and information gathered including statistical methods and fuzzy logic (Section 6.2 and Section 6.3);
f) methods of quantifying the safety performance assessment carried out on sites (Section 4.4); and
g) identification of MS Access as a suitable software to develop SPMT (Section 4.5).

Discussion with professionals from the industry

Following the information derived from the literature review, it was necessary to get real feedback from industry practitioners and set the framework for SPMT (Survey I), seek expert advice to develop indicators that could be used as measures (Survey II) and test the findings on a larger industrial sample (Survey III).

Survey I

Survey I determined the factors and sub-factors that affect safety performance on construction sites. Survey I was distributed to Principal Contractor (PC) and Specialist-Contractor (SC) teams to answer. A 30% response rate was achieved. The aim of the survey was to identify all the important factors and sub-factors that affect safety performance in the construction industry. The analysis of the survey is discussed in Section 7.2.

Survey II

After identifying all the important factors and sub-factors, the next stage was to develop indicators for each sub-factor. The hierarchy of SPMT is illustrated in Figure 4.3. Once the indicators were developed, they had to be validated for their contribution to the specific sub-factors. Survey II was carried out using expert opinion from ten ECI Safety Task Force members (Table 5.2). The response was very positive and the recommendations helped to define the appropriate indicators for each sub-factor. The analysis of the survey is discussed in Section 7.3.

Survey III

After carrying out Survey I and Survey II, all the important SCMs and indicators were identified for the inclusion into SPMT. The next stage was to validate the importance of the identified SCMs and indicators using bigger sample. This was done through Survey III. The sample selected for this validation exercise was the top UK contractors and top mainland European contractors for 1998. A 28% response rate was achieved. The analysis of this exercise was done using the fuzzy logic group decision-making using linguistic majority, which was discussed in detail in Chapter 6. The degree of importance automatically determines the weights of each SCM. The higher the degree of truth, the higher the importance. The survey also reveals how the companies carry out safety performance measurement at present. The analysis of this survey is discussed in Section 7.4.

10.1.2 Developing SPMT

The results of the literature reviews and the three surveys demonstrated the need for a proactive measurement tool. Hence, the thought of developing SPMT emerged. SPMT's development is discussed in Chapter 4. It was decided to use MS Access and MS Excel because they were noted to be widely used in the industry. Nevertheless, their capabilities of converting files to SQL (standard query language) provide easy interface with other computer database application i.e. SQL is a standard language for all kind of databases used. The database and spreadsheet packages are used to generate a solution to the industry safety problems instead of developing a bespoke software application. The reason for this is to ensure that SPMT will be a tool that will be operated on variety of computer-based databases. Section 4.5 discusses in detail the reasons for choosing MS Access. Designing using MS Access helped to quantify all the responses. SPMT involves the participation of all levels of personnel including, HQ management, site management, site supervisors, site operatives and specialist-contractors management using questionnaires, document checks and observations. Chapter 4 discussed this development in detail.

10.1.3 Implementation Of SPMT On Case Study Sites

Once SPMT was developed and the application software was validated against software validation rules, it was put for implementation and testing on on-going projects. Three companies agreed to participate namely Birse Construction Ltd, Mowlem Midlands and Kvaerner Process. Chapter 9 discussed the results of the testing.

The testing of SPMT revealed the following information:

- the overall site SPMT Index which reflected how the sites performed;
- the SCM performance score;
- the respondents influence on each SCM;
- highlighting the weak SCMs that needed urgent attention;
- reasons for the poor performance of the weak SCMs;
- highlighting the SCMs with excellent performance;

This implementation exercise revealed that SPMT was easily understood and implemented. The results had helped management to view the performance of their projects. Three sites performed within the 'very good safety performance' score for SPMT Index and one achieved a 'good' score. The second follow-up test showed improvement on weaker SCMs for both participating sites. The reliability comparison demonstrated the reliability of the SPMT questions.

10.2 CONCLUSIONS

In addition to inventing SPMT as a proactive safety performance measurement tool in accordance with the objectives, this research also reviewed the industry problems regarding safety and identified the issues that warrant further investigations. The conclusions that can be drawn to establish the issues investigated for this research include the following:

1. there is a need to enhance the safety culture in the construction industry;
2. the construction industry still measures safety performance against accident statistics even though they may adopt a proactive approach;

3. there is a critical need for a proactive safety measurement tool for the construction industry;
4. there is a need to involve all categories of personnel in safety performance assessment;
5. the methods adopted to carry out the performance should be generic and comprehensive;
6. feedback of results of assessment should be informative, able to convey areas of weakness, and able to inform remedial actions; and
7. the future potential of SPMT as a generic safety performance measurement tool has been demonstrated.

10.2.1 Enhance Safety Culture In Construction

Safety culture of an organisation is essentially a description of the attitudes of personnel about the company they work for, their perceptions of the magnitude of the risks to which they are exposed and their beliefs in the necessity, practicality and effectiveness of controls. The safety culture, a sub-set of the overall organisational culture is now believed to be a key predictor of safety performance. A positive safety culture implies that the whole is more than the sum of the parts. The many separate practices interact to give added effect, and, in particular, all the people involved share similar perceptions and adopt the same positive attitudes to safety – a collective commitment. Studies by Booth et al (1995), Grote et al (1996) and Ostrom et al (1996) revealed that the dominant themes to emerge were:

- the crucial importance of leadership and the commitment of the chief executives;
- the safety role in site management;
- involvement of all employees;
- openness of communication; and
- demonstration of care and concern for all those affected by the business.

10.2.2 Measure Safety Performance Against Accident Statistics

The construction industry still measures safety performance against accident statistics even though they may adopt a proactive approach. Accident prevention requires the creation and maintenance of a safe working environment and promotion of safe behaviour. Safety management effort has been directed at the prevention of repetitions of accidents that have already occurred, largely on the basis of information derived from detailed accident investigations. The main reason, according to Booth et al (1995) for why safety management has concentrated on reactive prevention is that it is easier to deal with than proactive prevention. Assessing risks and devising plans without the help of data is difficult; it involves weighting the probabilities of a wide range of unwanted outcomes and preparing an integrated control plan to cope with all the hazards detected.

The reasons that reactive data is limited in function to measure safety performance are as follows:

- data tends to be limited to factors about the victim such age, gender and occupation- thus lacks other information such as environmental conditions, task factors and behavioural factors;
- the reports only include activities which were directly and immediately involved in the accident. The failure to look towards understanding the factors causing the unsafe behaviour limits the suitability of most accident reports;
- for each fatality or serious accident there is a large number of minor accidents and correspondingly, a much larger number of unsafe acts and hazardous situations;
- inefficiency of reporting where important information were missed out; and
- under-reporting of accident and cases of ill-health disguises the true accident situation.

10.2.3 Proactive Safety Performance Tool For Construction

It was found that the construction industry needs measurement techniques that are able to do the following:

- describe the safety level of a project;

- measure safety performance that helps to prevent and not just record accidents;
- describe when and where to expect trouble and provide guidelines concerning what should be done about the problem;
- report continuously on the change in safety level within an organisation and to evaluate the effects of accident prevention efforts as rapidly as possible;
- measure the presence of safety instead of lack of safety.

Therefore the best approach to measure safety performance for construction is using proactive measures. Proactive measures for safety performance measurement are able to describe the relative level of safety and can continuously report fluctuations. This positive approach will also be able to identify behaviours and conditions that have the greatest potential to contribute to accidents. Most important, this approach is able to identify the weaknesses in safety performance before an injury or accident actually occurs, thus enabling remedial action to be planned.

10.2.4 Involvement of All Categories Of Personnel In Safety Performance Assessment

The measurement tool that was discussed above generally encourages a more proactive approach with good management practice and the transfer of ownership of safety to every employee. Employees should recognise that the key determinant of successful management is the promotion of a positive safety culture and that good safety performance is not just a matter of the preparation of well-structured company safety procedures. What is crucial are the attitudes and beliefs of directors and all employees to the procedures. Where everyone believes that the control measures are appropriate in relation to the risk, workable and effective, there is prospect of willing compliance with the safety measures.

It is also essential to check that the policies and procedures set up by HQ and site management are actually implemented on site and the best way to establish this is to ask the operatives.

10.2.5 The Performance Measurement Adopted Should Be Generic And Comprehensive

While the need for safety performance measurement is clear, most attempts result in unsatisfactory measures. Visser (1993) states any attempt to collect consistent data industry wide must be tailored to suit the information that is readily available. Visser agrees that if statistics are to be used to monitor industry safety performance, it is extremely important that common and consistent records/data be collected industry-wide. Confidence in industry safety performance will not grow until a set of data besides accident figures is available that honestly reflects industry status with respect to safety performance. If industry cannot accurately measure performance, it cannot manage it. Furthermore the commitment to safety appears extremely hollow if performance data are not available to back it up. Statistical data allow performance to be measured and provide feedback enabling management to manage safety professionally.

10.2.6 Feedback Of Assessment Results

Feedback of results of assessment should be informative, able to convey areas of weakness and able to inform remedial actions. Any assessment of safety performance must be able to provide both absolute and relative measurements. What is important is that the assessment is able to evaluate the magnitude of change over time and perform comparative evaluations of periodic assessments. The measurement concepts must be capable of a reasonable degree of standardisation over time. Once an assessment has been carried out, it must be able to identify areas of weakness and allow management to plan remedial actions. Periodic assessment will allow management to assess changes for the better or worse especially on the weaker safety factors.

10.2.7 The future potential of SPMT

SPMT was designed to be a generic measurement tool that is applicable to any construction site at any phase (conclusion 5). The development of SPMT as a proactive measurement tool reduces the dependency to measure safety against reactive data (conclusion 3). SPMT also involves the participation of various levels of personnel from HQ management to operatives (conclusion 4). The feedback of results from carrying out SPMT are informative and able to highlight the detail performance of each SCM. Each assessment will be able to highlight the SCMs that performed weakly hence enabling management to plan remedial actions (conclusion 6). Overall SPMT has the potential to be a generic measurement tool to enhance safety culture on a project (conclusion 1).

10.3 RESEARCH ACHIEVEMENTS

The research has contributed to the knowledge of safety performance and provided a prototype measurement tool called SPMT. SPMT has been developed and field tested. . SPMT assessment yields the following information:

- the project safety performance level;
- the analysis of the performance of each SCM;
- the respondents influence on SCMs; and
- the excellent and the weak SCMs.

SPMT site assessment results allow the following comparisons to be made:

- comparative evaluation with other projects;
- comparative evaluation with projects with same regional management;
- comparative evaluation with periodic testing; and
- comparative evaluation with reactive data.

In addition to the actual development of SPMT, the research also contributes to safety performance research by addressing a number of underlying factors. These aspects can be used for furthering safety performance research.

1. The establishment of thirty SCMs to measure safety performance on sites. These thirty SCMs have undergone a rigorous validation process to ensure that only the important factors are chosen for SPMT. Three levels of surveys were adopted in this process. The SCMs were chosen to best represent generic safety factors affecting safety performance on site and should form the basis of any measurement system.

2. 'Best practice' advice for each SCM has been developed in order to help the management to improve its performance. This was developed based on current practices, literature reviews and expert opinion. This information will aid management to design action plans to tackle weak SCMs. This guide will ensure that management is taking the right steps to deal with the situations and should in itself form the basis of training material for site personnel.

3. This research had also developed a scoring method to calculate safety performance. It is easily implemented and understood. The design was based on a matrix recommended by Objective Matrix or OMAX approach widely used to measure productivity. The matrix consists of five main components as follows:
   - the performance criteria of SCMs (what is to be measured);
   - the performance scale (which compares the measured value of the criterion to a standard or selected benchmark value);
   - the weights (which determine the relative importance of each SCM to each other and to the overall measure of safety performance);
   - the value (which is the result of multiplying the score with the average); and
   - finally the performance index that is the SPMT Index to indicate and track performance (which totals the sum of each SCM value).

   Lessons here could inform the development of other tools for measuring performance.

4. SPMT was designed as a computer-aided object-based interactive assessment tool to measure safety performance on site. An interactive tool would be able to feedback the correct information much faster and thus save time. For this situation, Microsoft (MS) Access was chosen, as it is a powerful database package

and a development tool under Microsoft Windows which ensures wide applicability. The Windows environment means that the software responds to events performed by the user by means of clicking an icon or selecting menu options. MS Access also supports dynamic data exchange (DDE) and object linking and embedding (OLE) thus allowing easy exchange of data between MS Access and MS Excel spreadsheet. This shows that MS Access could be used as a platform for various site measurement and data collection applications.

As a result of this research the following publications have been produced:

1. Kunju Ahmad, R., Gibb, A.G.F. and McCaffer, R. 2000. SPMT – Development of a computer–aided, interactive safety performance measurement tool for construction. *The International Journal of Computer Integrated Design and Construction (CIDAC)* (accepted for publication).

2. Kunju Ahmad, R., Gibb, A.G.F. and McCaffer, R. 1999. Methodology to develop a proactive safety performance measurement technique. *Proceedings of the Second International Conference of CIB working Commission W99.* Hawaii, pp 507-514.

3. Kunju Ahmad, R., Gibb, A.G.F. and McCaffer, R 1998. Methodology to develop an effective safety performance technique. *ARCOM Conference,* September, Vol. 1, pp 281-290.

10.4 FURTHER RESEARCH

This thesis has demonstrated the development of SPMT and its application on a small sample of sites. Overall SPMT has the future potential to be a generic measurement tool that is easily implemented on any construction site. Nevertheless, currently SPMT has limitations and further work should be able to improve its prospective applications. The following are some areas for future work:

1. The pilot testing of SPMT has demonstrated its viability and validity to the industry. The more implementations and results that can be obtained, the better the comparisons that can be made. This will also help to study the correlation between reactive data with SPMT performance. Through further testing, evaluations on the theoretical weightings for respondents, indicators and SCMs can be carried out.

2. The tests show that SPMT has the potential to be updated and adopted by industry-wide bodies such as the HSE for certification to organisations. SPMT can be made generic and provide a basis for a standard measure of safety and industry certification by an accrediting professional body.

3. Currently, SPMT is developed using Microsoft Office based applications with the use of SQL language with interface with other applications. It is recommended to be adopted by software vendors who will write stand-alone software for global use and customisation by individual users. The ECI Safety Task Force is currently considering the further development of SPMT.

4. Currently, information communication technology (ICT) has various devices from hand held computers to mobile phones. The future of SPMT software should consider these developments for effective applications on site.

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APPENDIX1.1 – LIST OF ECI SAFETY TASK FORCE MEMBERS

Appendix 1.1 –

THE SAFETY TASK FORCE MEMBERS OF THE EUROPEAN CONSTRUCTION INSTITUTE

1.	Ray Canning	Taylor Woodrow Construction Ltd, UK
2.	Bill McGillivray	Brown and Root Aberdeen, UK
3.	Dirk Hessing	ABB Lumus Global BV, Netherlands
4.	Guido Simons	Fluor Daniel BV, Netherlands
5.	Trevor Thompson	Kvaerner Process (UK) Ltd
6.	Peter Brown	Bechtel Ltd, UK
7.	Ian Burgess	Alstom Automation Ltd, UK
8.	Steve Pearson	BG plc, UK
9.	Roy Greenslade	AMEC Process & Energy Ltd, UK
10.	Terry Skinner	National Power plc, UK (now Innogy)
11.	Carsten Mink	Lurgi Oil Gas Chemie GmbH, Germany
12.	David Stewart	Foster Wheeler Energy Ltd, UK
13.	Keith Rendel	MW Kellogg, UK
14.	Jean Luc Dumas	Technip, France

APPENDIX 3.1– LIST OF EXISTING SAFETY PERFORMANCE ASSESSMENTS

APPENDIX 3.1

EXISTING SAFETY PERFORMANCE ASSESSMENT APPROACH

1.0 Introduction

The following discussions describe the existing safety performance measurement approaches adopted by different organisations. These approaches also include research undertaken to improve safety performance. The discussions are divided as follows:

1. Safety audit
2. Behavioural approach and safe working
3. Safety culture /safety climate
4. Proactive safety performance
5. Safety training system
6. Reactive performance
7. Benchmarking

2.0 SAFETY AUDIT

This section discussed the following safety audit assessment:

- performance rating;
- elements of loss prevention management;
- three levels of audit;
- TOTAL;
- ISRS;
- PRIMA;
- REALM;
- CHASE; and
- Operating discipline.

2.1 Performance Rating –(Magyar 1983)

A well designed safety audit programme is one that:

- management can participate in and feel comfortable with;
- provides an 'objective' means for evaluation of the elements which are essential to injury – less control (i.e. safety performance);
- provides the basis for establishment of objectives and the 'real measurement of real progress';
- can be used as the base for a safety award or incentive bonus programme; and
- continuously generate observable improvements in the way people work.

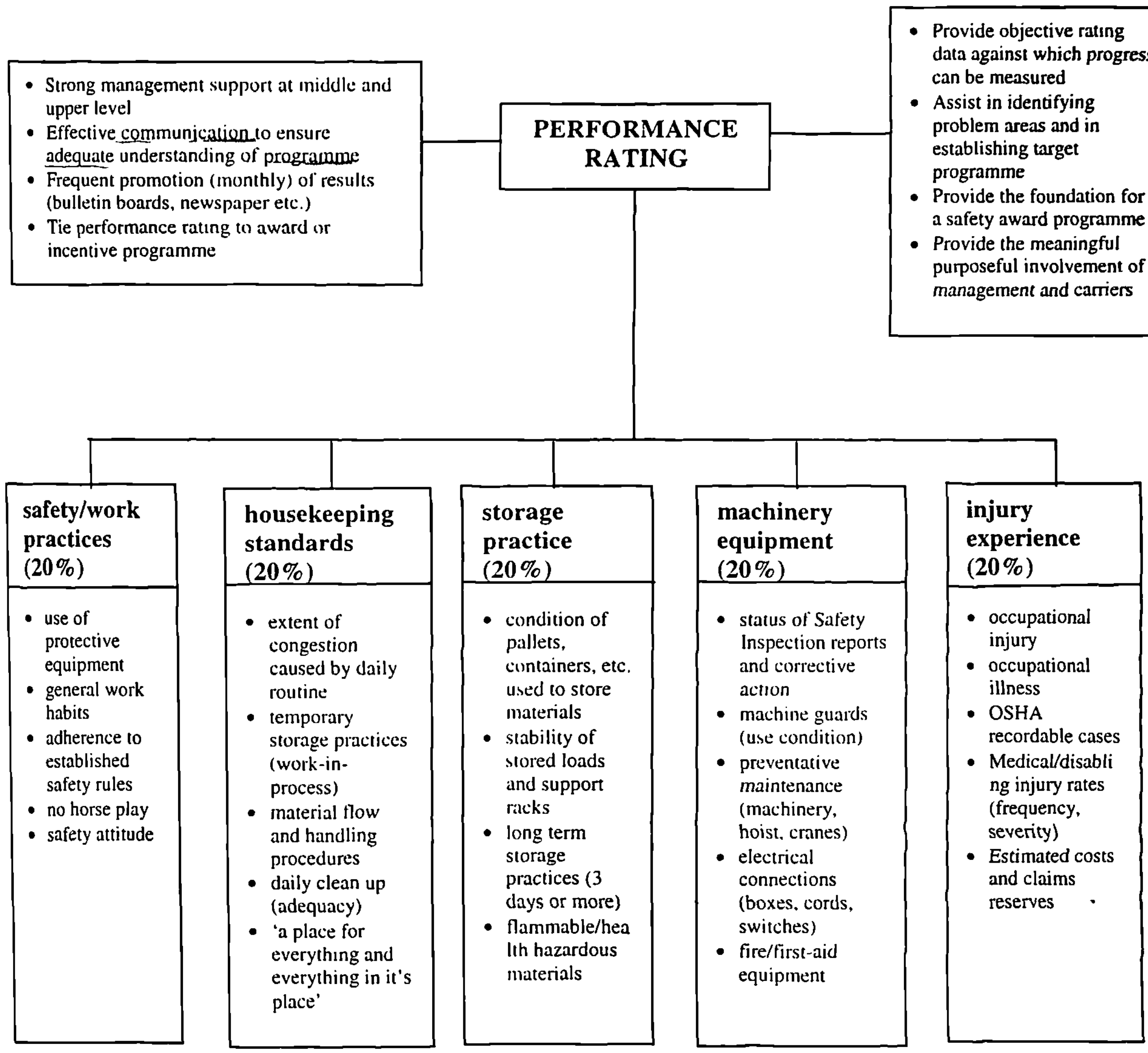

Figure A3.1 – Basic safety audit (Magyar 1983)

Each level evaluated should be weighted equally at 20% and the rating should range from poor to excellent. A good safety audit programme should have the following general procedures:

Safety performance audit

- carry out audit twice a month for the entire operation;
- the first safety audit is carried out during the first two weeks of each month and will be unannounced; and
- the second safety audit will be announced in advance and will occur sometime during the last week of each month.

Audit area

- operations should be divided into clearly defined units or areas for auditing purposes;
- areas of jurisdiction should not overlap (audit should be conducted on building-by-building basis rather than function-by-function basis).

Safety performance

- three auditors will conduct each audit : two will be selected by the safety director and the third will be the manager responsible for the area being audited.

Audit responsibilities

- the auditors will walk around each of the areas to be audited;
- the two appointed auditors will complete a rating sheet for each area audited;
- the third auditor (manager of the area) will record all deficiencies noted during the audit; and
- ratings will be reviewed at the conclusion of each audit.

Audit results

- all ratings will be averaged and weighted;
- an overall rating for monthly safety performance will be computed for each area audited; and
- the calculation is as follows:

Rating for each section
= average (1^{st} announced + 2^{nd} announced audits) x section factor

Total safety performance rating
= Σ (ratings for all sections + injury experience*)
where, * injury experience is calculated as follows:

$$= \frac{\Sigma \text{ employees} - \Sigma\ 1^{st} \text{ treatment injuries}}{\Sigma \text{ employed}} \times \text{section factor}$$

Monthly audit performance

- A monthly safety performance report will be compiled and is issued by the safety director;
- Areas where corrective action is needed will be noted and the areas will be placed in rank order according to safety performance; and
- Follow-up should be management team effort with the responsible manager providing the resources needed and the safety director co-ordinating the effort.

The safety performance rating programme outlined has produced teamwork and competition among members of management and the rank and file. All employees working in the area that receives the highest monthly performance rating are eligible for the monthly safety award.

2.2 Elements of Loss Prevention Management- (Waldram 1991)

Safety audit is a means of monitoring managerial aspects of the safety policy including the performance of contractors.

Mobil E & P Division bases its formal audit system on the eleven Essential Elements of Loss Prevention Management:

1. Leadership, commitment and accountability
2. Hazard identification, evaluation and control
3. Rules, regulation and procedures and personnel selection and placement

4. Skills, safety and management training
5. Communication
6. Purchasing and engineering control
7. Protective equipment
8. Incident/accident reporting, investigation and analysis
9. Emergency preparedness
10. Audit

The most effective method for clients to ensure compliance with H&S requirements was judged by contractors to be 'periodic meetings and reviews'. Auditors should review and refine their criteria, using experience gained on audits. The upgraded criteria can then be used as a basis for further improvements to the safety management system and associated procedures.

A close alignment exists between audit techniques and the principles of quality management to BS 5750 (ISO 9000 series) (Figure A3.2). Auditing will result in improved safety standard provided that audit recommendation are incorporated into management procedures and these procedures are implemented in the workplace.

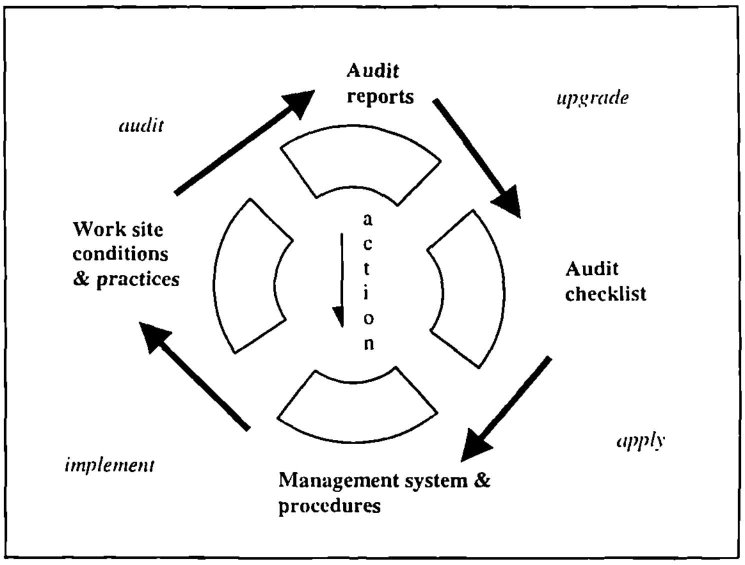

Figure A3.2 – The audit process (adapted form Waldram 1991)

2.3 – Three levels of audits – (Byrne 1996)

At Shell Expro, three levels of audits were carried by a combined Shell and contractor team:

Level 1 – The Corporate Audit
- a process of review of business control (i.e. policy, organisation, supervision, procedures, review and appraisal);
- to establish they are applied effectively and efficiently and comply with company requirements.

Level 2 – The Field Unit Safety Case Audit
- to verify that the Fields Unit's installation safety case is working as intended and that the hazard management process is implemented and effective;

- verifies that the safety case accountabilities and contractors responsibilities are complied with.

Level 3 – The Location Audit
- process of activity and task verification to confirm compliance with standards and procedures referred to in the safety case;
- an audit plan is prepared annually which covers all the specific activities.

Activities such as inspection, physical condition monitoring and unsafe act auditing etc. are not included within the framework, they are considered to be part of supervisory skills involved in implementing of the Safety Management System.

Results of audit implementation is reduction in Lost Time Injuries (LTI) as demonstrated by Byrne is as follows:

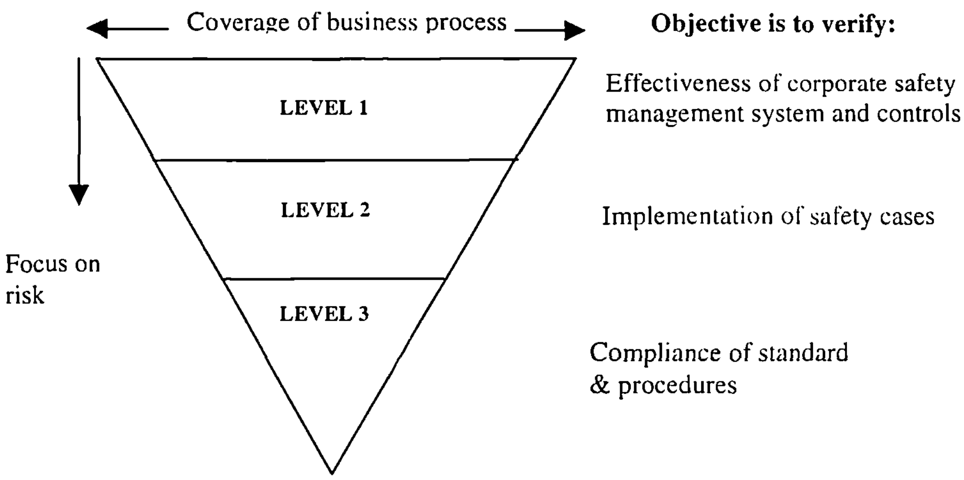

Figure A3.3 – Levels of audit (adapted from Byrne 1996)

2.4 TOTAL – (Cote. et al 1991)

TOTAL was developed and refined a specific methodology to assess the operating and safety conditions of hydrocarbon processing installation. The methodology had proven to be extremely effective to highlighting existing or potential hazards, due to the following techniques:
- a detailed survey of facilities and documents;
- the use of a comprehensive check-list that enables:
  - a break down of complex issues into simpler elements which are easier to add;
  - careful investigation into activities where hazardous occurrence arise;
- a series of exercises and tests which assess plant conditions, site organisation and personnel behaviour;
- a reporting system that keeps the operating company in touch with the auditors; and
- a rating system to provide precise reference which enables comparison with other installations.

Audit starts on the first day with a presentation by the team leader on the objectives of the audit, the scope of work, the schedule and the procedures. The presentation is attended by the head of department involved in the audit within the immediate subordinate if necessary, and those responsible for operating the plant and equipment. The audit concludes with another presentation in two parts reporting the main findings that are:

- on site to operational personnel; and
- in the operating company HQ to operation and technical managers and possibly to general managers.

Procedures

1. Survey all equipment and activities listed as reference check list through site inspection
   - Section 1 Operation and safety organisation
   - Section 2 General safety practices
   - Section 3 Process hazard controls
   - Section 4 Technical condition of the installation
   - Section 5 Test and exercise

2. Physical investigation of the facilities is carried out with simultaneous cross-checking of available drawings and engineering documents.
3. Physical screening of documentation.
4. Exercise drills, tests concerning process and safety equipment

Assessment

Each system is analysed and evaluated item by item using audit cards, which feature:

1. The present status of the system.
2. The conclusion using standardised wording
   - Excellent (high standard – an example to others)
   - Satisfactory (can stay as it is, improvement is not required; recommendation may be implemented)
   - Below average(improvement is recommended, but not compulsory; recommendation should be implemented)
   - Not acceptable (improvement shall be made; recommendation shall be implemented)

2.5 ISRS – (Bond 1985)

International Safety Rating System (ISRS) originated in the mid-1970s when studies of organisations world wide which were performing best in safety fields revealed certain characteristics common to the management systems employed, irrespective of the industry concerned.

These features included visible management involvement with site visits, comprehensive job analysis procedures, safety training at all levels, structured inspections and follow-ups. Building on this framework the International Loss Control Institute (ILCI), developed the prototype 5-star system. Collectively this is known as ISRS.

The advanced system comprises twenty elements and each element is broken down into a number of questions. There are about 640 in all, most require yes/no answers, and only 10% require professional judgement. Answers are given points according to their importance. About 10,000 points are the maximum possible. The system is updated annually at a convention of accredited auditors. The audits are carried out by trained auditors.

A rating of one to five stars is earned based upon:

a) The evaluation of a mandatory number of the 20 elements plus optional selected elements (10 total elements for one star rating; 12 for two star rating; 15 for three star; 18 for four star and 20 for five star).
b) An average overall percentage score is required for all rated elements (% of 10,000 total points available).
c) The percent score on any rated elements cannot be below specified minimum.

The elements that are audited are as follows:

1. **Leadership and Administration**
   - General policy
   - Safety cordinator
   - Senior and middle management participation
   - Establish management performance standards
   - Management participation
   - Presentation at management meetings
   - Management reference manual
   - Management audit conducted
   - Individual responsibility for H&S
   - Establishment of annual H&S objectives
   - Joint H&S Committee and/or safety representative
   - Refusal to work on grounds of H&S Hazards
   - Reference library

2. **Management Training**
   - Management induction
   - Formal initial training of senior management personnel
   - Formal review and update training for senior management personnel
   - Formal initial training of supervisory and middle management personnel
   - Formal review and update training of supervisory and middle management personnel
   - Formal training of the programme co-ordinator

3. **Planned Inspection**
   - Planned general inspection
   - Follow-up procedures
   - Inspection report analysis
   - Critical parts/items
   - Preventive maintenance
   - Mobile and material - handling equipment; pre-use inspection
   - Substandard of hazardous conditions reporting

- Planned general inspection
- Regular programme monitoring

4. **Task Analysis and Procedures**
   - Management directive
   - Critical task inventory
   - Task analysis and task procedures for critical tasks
   - Safety and health hazards in critical task analysis and procedures

5. **Accident/incident Investigation**
   - Accident investigation procedures
   - Scope of accident/incident investigation
   - Remedial follow-up action
   - Major accident
   - High potential incidents (near misses)
   - Operating management participation
   - Incident (near miss) reporting and investigation
   - Accident/incident report maintenance
   - Regular programme monitoring

6. **Task Observation**
   - Management directive
   - Complete task observation programme
   - Level of complete task observation
   - Partial/spot task observation
   - Task observation report analysis
   - Regular programme monitoring

7. **Emergency Preparedness**
   - Leadership and administration
   - Emergency plan
   - Supervisory training in first aid
   - Employee training in first aid
   - Emergency lighting and power
   - Source of energy control
   - Protective and rescue equipment
   - Emergency team
   - Qualified first aid attendants
   - Organised outside help and mutual aid
   - Protection of vital record
   - Post event planning
   - Emergency communication
   - Communication to the public

8. **Organisational rules**
   - General health and safety rules
   - Specialised work rules
   - Work permit and specialised procedures system

- Rule education and review programme
- Rule compliance effort
- Use of educational signs and colour codes
- Regular programme monitoring

9. **Accident/incident analysis**
   - Performance statistic computed and used
   - Occupational injury and illness and illness analysis
   - Property and equipment damage identification and analysis
   - Problem solving project teams
   - Incident (near miss) analysis

10. **Employee Training**
    - Training needs analysis
    - Employee training programme
    - Training programme evaluation

11. **Personal Protective Equipment (PPE)**
    - PPE standard
    - PPE record keeping
    - Enforcement of standards
    - Regular programme monitoring

12. **Health Control**
    - Health hazard identification
    - Health hazard control
    - Information/training/education
    - Industrial hygiene monitoring
    - Health maintenance programme
    - Professional assistance
    - Communication
    - Records

13. **Programme Evaluation System**
    - Evaluation of management compliance with programme standards
    - Evaluation of compliance with standards for general physical conditions
    - Evaluation of compliance with fire protection and control standards
    - Evaluation of compliance with occupational health standards

14. **Engineering control**
    - Design engineering consideration
    - Process engineering consideration
    - Regular programme monitoring

15. **Personal communication**
    - Training in personal communication techniques
    - Job induction
    - Task instruction

- Planned personal interviews
- Regular programme monitoring

16. Group meetings

- Group meetings
- Record keeping
- Management involvement
- Regular programme monitoring

17. General promotion

- Safety bulletin board programme
- Use of programme statistic and facts
- Critical topic promotions
- Use of awards or recognition
- Programme information publication
- Group performance promotion
- Housekeeping promotion
- Records of programme promotion activities

18. Hiring and placement

- Physical capability requirements
- Physical examination
- General induction programme
- Pre-employment/pre-placement qualification

19. Purchasing control

- Procurement of goods
- Selection and control of contractor

20. Off-the-job safety

- Problem identification and analysis
- Off-the job safety education

The reference library provides the resource of safety knowledge for the organisation. It should include sufficient information on all standard safety practices, equipment and programme aids relative to the organisation's activities and off-the-job activities of the people. ISRS is not a simple tool. It must be emphasised that it requires involvement from the top management.

2.6 PRIMA – (Hurst. et al 1996)

Application of Safety Attitude Survey Questionnaire (SAQ) and Process Safety Management System (PSMS) audit tool called PRIMA (Process Risk Management Audit) at six major sites in four European countries.

SAQ was available at the outset of the project while PRIMA was developed within the project from an earlier prototype. Aim of the work was to compare these quantitative measures with accident performance data for the six sites, to test the hypothesis that good performance in the assessed PSMS performance and positive attitude to safety would be reflected in good accident performance.

PRIMA has the following characteristics:

1. Eight key audit areas
   - Hazard review of design (DES/HAZ)
   - Human factors review of maintenance (MAINT/HF)
   - Checking/supervision of maintenance tasks (MAINT/CHEC)
   - Routine inspection and maintenance (MAIN/ROUT)
   - Human factors review of operations (OP/HF)
   - Checking/supervision construction installation (CONS/CHEC)
   - Hazard review of operations (OP/HAZ)

2 A model of an ideal PSMS defined by the control and monitoring loop, which covers both PSMS design, implementation, monitoring and revision. The control and monitoring loop includes consideration of the levels of the organisational hierarchy which can affect process safety. The control loop defines four anchor points.

3 A set of four themes within each audit area.

4 A question set which provides detailed questions to guide the author during audits.

5 An audit manual which describes the audit methodology and practical aspects of auditing

6 A calculation method to generate the modification factor.

For each area of audit e.g. (DES/HAZ) comparison is made with the strength of the control and monitoring loop found during the audit with four anchor loops which represent:

- the ideal boundary
- the ideal/good boundary
- the poor upper boundary
- a poor control area

The formula to calculate the failure rate modified with the results from PRIMA is

$$\text{Logfail}_{PSMS} = \text{logfail}_{G} + \Sigma\, a(i)\, x(i)$$

Where Logfail_{PSMS} is the ($-\log_{10}$) failure rate adjusted by the PRIMA result audit; logfail_{G} is the ($-\log_{10}$) unmodified generic failure, x(i) is the scaling factor and a(i) is a weighting for each audit area. Weightings are derived from accident analysis.

Safety attitude questionnaire (SAQ)
The SAQ was distributed to all participants. The rating score varies between 1 and 7 corresponding to very strong agreement or disagreement.

The strength of the PRIMA system is that is has a sound theoretical and statistical basis. Its origin in research gives it credibility and it addresses issues which have been shown to be important in previous incident investigations. On the other hand, the method is demanding on the auditors. The strength of the correlation between attitude scale scores and self reported accident rate is not sufficient to allow predictions of accident rates from scale scores in all individual cases.

2.7 REALM – (EPSC 1996)

The BP group is an integrated hydrocarbon company operating in more than 70 countries worlwide. Health, safety and environment (HSE) matters have long featured as issues of importance in BP. The whole approach to HSE is driven from the very top of the company. The HSE management system is shown Figure A3. 4. Its starts with the HSE policy, issued by the main board of the company, and signed by the group chief executive.

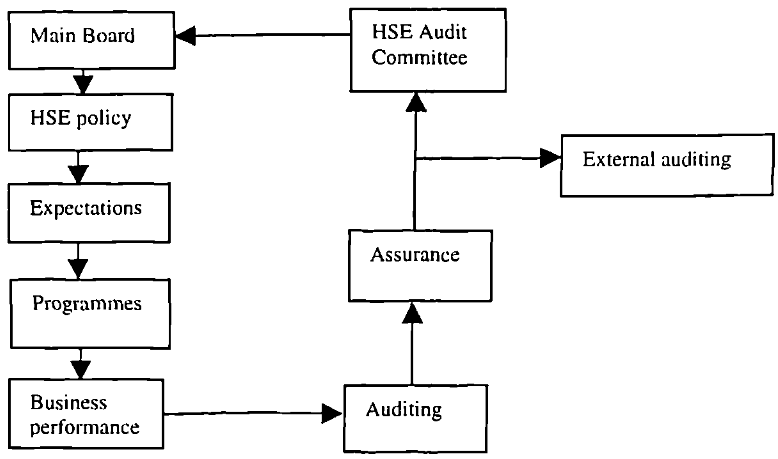

Figure A3.4 – HSE management in BP (EPSR 1996)

The BP Oil Business Unit is responsible for continually reviewing and measuring their own performance against the expectations and their own site-level requirements. There is a strong focus on HSE auditing, which has always been seen as fundamental to that process.

The way forward – REALM (resource efficient auditing for line management)
A global cross-business team looked at the problems and developed a solution which not only removed many of these difficulties but also helped to integrate HSE further into the line management processes and thinking. The proposed framework was a 'one stop' system which delivered: a means of auditing, a tool to help managers set HSE plans and targets, a mechanism to facilitate sharing and comparing between Business Units. The framework is known as REALM (Figure A3.5). The framework has two parts:

1. A management system component (REALM1) essentially common across all elements of HSE
2. A technical/physical conditions framework (REALM2), subdivided according to the HSE disciplines.

	HEALTH	SAFETY	ENVIRONMENT	PRODUCT STEWARDSHIP	SECURITY
Management	REALM 1				
Technical issues • people • procedures • equipment	REALM 2 HEALTH	REALM 2 SAFETY	REALM 2 ENVIRONMENT	REALM 2 PRODUCT STEWARDSHIP	REALM 2 SECURITY

Figure A3.5 – Business unit HSE *management*

The benefits of this process are many but include:

- an open, transparent process involving 'bottom-up' ownership and hence greater chance of implementation, of a set of well-tried systems;
- accreditation against external management system requirements with minimum internal disruption; and
- systems tailored to need.

Proactive measurement of safety performance has to integrate with the management system. The ability to measure performance on a regular and consistent basis provides the essential feedback to keep the system alive.

2.8 CHASE - (HASTAM 1999)

HASTAM established in 1984, as an offshore of the Safety Development of Aston University is now an independent company employing multi-displinary team of health, safety and environmental specialist. It has developed a suite of evaluation packages under the CHASE banner. CHASE (Complete Health and Safety Evaluation) is a unique management tool designed for both monitoring by line managers and auditing by safety professional.

The CHASE system

- follows the philosophy of BS 8800 and the 2nd edition of the HSE publication 'Successful Health and Safety Management';
- helps established procedures for risk assessment;
- helps procedures for controlling risk;
- identifies health and safety training needs;
- provide an effective means of monitoring and auditing health and safety performance;
- reinforce the role of line managers in the management of safety;
- provides an effective self training tools for managers; and
- leads to cost effective safety management.

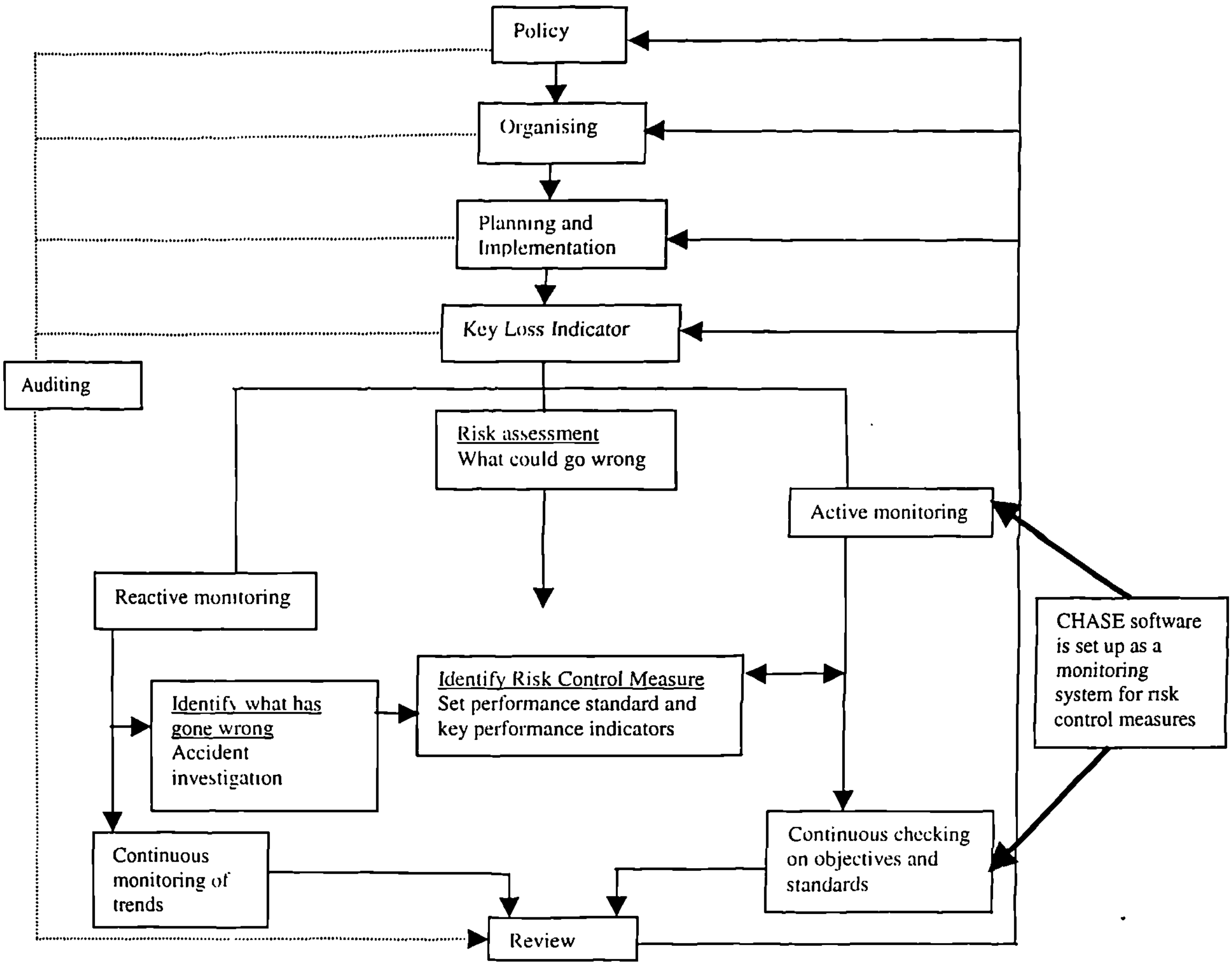

Figure A3.6 – Risk management through partnership (HASTAM 1999)

CHASE for windows is a powerful software package designed to cut the time required for recording and analysing evaluation data. The software uses sets of questions (modules) which are available from HASTAM or which can be created by the clients. Users can,

- tailor CHASE questions to suit their own needs;
- design audits from scratch; and
- use existing audits.

The package will automatically

- produce data graphically;
- produce an action plan;
- score the answers and questions and analyse the results;
- adjust the scores of individual questions do not apply; and
- analyse sub-set questions, e.g. training, using the tag facility.

The CHASE for window requires Microsoft Windows 95 or Window NT 3.51 or later. The database is a Microsoft Access version 7.0 with a C++ front end.

2.9 Operating system – (EPSC1996)

Dow Chemical Company has developed a system called 'operating discipline'. This is a system of self-audit against a range of environmental health and safety standards and objectives. Specialists at the location help plant personnel to complete the questionnaire and review. Operating discipline is the documentation and use of the collective best knowledge and experience that ensures each job can and will perform successfully. There are 13 areas where the operating discipline management system is defined. Each of these areas is given substance and complete descriptions which will allow the people operating the safety management system to see exactly where they are on a scale of 1-6.

The operating disciplines are:

- management of change;
- process technology documentation;
- training;
- safety process;
- process risk management;
- operating procedures;
- process control;
- operational reliability;
- dynamic process information;
- product and service quality;
- environmental;
- industrial hygiene; and
- administration.

Six key elements are addressed in evaluating each operating discipline and they are:

- procedure;
- reviews;
- documents;
- communication;
- training, and
- audits.

The analysis of validation is done by comparing the individual elements against the management standard for each section. The management standard is mandated by the 'Governance Board' of Dow Chemical Company. The comparison against the management standard is done during the audit programme.

3.0 BEHAVIOURAL APPROACH TO SAFE WORKING

This section discussed a proactive approach to measure the behaviour approach as reported by:

- Ramsey et al (1986)
- Hubler W.G. (1995);
- Duff et al (1993).
- Walker G.C.W. (EPSC 1996);
- Top W.N. (EPSC 1996);

3.1 Ramsey J.D. et al (1986)

The purposes of this study were to develop a classification system or taxonomy of unsafe behaviour and demonstrate its validity as a tool for identifying casual factors and for evaluating safety related performance. The resultant categorisation was divided into three major types of unsafe workers behaviours: those related to the worker, those related to tools, equipment or materials and those related to material handling equipment.

Taxonomy of unsafe worker behaviour:

1. Related to workers
   - improper use of body;
   - unsafe position or posture;
   - unsafe body movements;
   - failure to use protective clothing; and
   - failure to dress properly.

2. Related to tool, equipment or material
   - tools, equipment or material errors;
   - unsafe placing of tools, equipment or materials;
   - failure to shut down potential energy; and
   - making safety device or equipment inoperative.

3. Related to material handling equipment
   - relating to crane, hoist or fork truck;
   - relating only to crane and hoist; and
   - relating only to fork truck.

Implementation

60 observations were taken daily during the 14-month study period by the trained observers. This resulted in 17841 worker observations. Each worker was observed for approximately 30 seconds. The results is 16107 of the 17841 observations were classified safe behaviour while only 1734 were classified as unsafe behaviour. Out of 1734 observations, 22% are related to tools, equipment or materials, 5% were related to materials handling equipment and the rest related to related to workers. Based on the results, appropriate corrective actions were recommended to reduce unsafe worker behaviours.

This study demonstrates the viability of measuring safety performance before an accident through the use of safety sampling procedures and a classification system or taxonomy of unsafe worker behaviours. The behavioural activities that tend to be unsafe acts can be categorised and used as a basis for the development and initiations of preventive or corrective actions.

3.2 Hubler W.G. (1995) - BAPP

The Behaviour Accident Prevention Process (BAPP) was developed by Behavioural Science Technology (BST), California. BAPP takes DuPont STOP programme further upstream by identifying, defining and scientifically measuring critical behaviours which are essential to performing a specific job safely (see section 5.1 in Appendix 3.1 for further explanation of STOP). The objective of BAPP is to increase the proportion of time that crews perform certain critical behaviour safely, and therefore eliminates the likelihood of employee injury.

Implementation of the behavioural accident prevention process consists of five steps. The first is to develop an inventory of critical behaviours for frequently occurring injuries or accidents. This step is performed by a steering committee or work teams who identify safe work behaviours and define the tasks in operational terms. The second step is to present the inventory of critical behaviours to the work force for review and endorsement. The objective is to ensure the employees understand and agree to the operational definition of safe behaviour, which they will be measured by.

The third step is to measure the baseline %SAFE activity of the operatives. Measurement is conducted through behaviour sampling – comparing observed work behaviours to the definitions established by the crew themselves. A ratio of the number of safe activities versus the total number of activities observed leads to the calculation of %SAFE activity. The resulting figure represents the frequency of exposure to work related injury. The lower the ratio, the grater the exposure to injury due to unsafe behaviour. The fourth step is to present the %SAFE baseline to the workforce. The %SAFE baseline will become the benchmark by which future safety performance is compared. The final step is to establish a mechanism for continuous improvement. The mechanism includes peers delivering immediate feedback to co-workers on safe and unsafe work practice.

Implementation of BAPP requires the effective planning, facilitating, observing and training. Planning begins with development of an overall plan of action and the critical behaviours inventory. Good facilitating is important to the success of the inventory review with crews and gaining their endorsement for how to perform tasks safely. Observing is essential in developing %SAFE baseline of the activity and sustaining the continuous improvement mechanism. %SAFE measures how safely tasks are being done and identifies how likely an injury is to occur. %SAFE reflects the real safety performance. Finally, training for management, supervisors and field employees transcends the implementation effort from beginning to end.

3.3 Duff et al (1993)

The authors in this research developed an objective and quantifiable method of safety measurement by identifying contributory factors in the chain of events which causes accidents. This was done by

a. sorting the accident data by department;
b. identifying the different types of accident within each department; and
c. classifying on the basis of whether or not the individual's behaviour or situation had contributed to the accident.

Four composite measures of safety: scaffolding; access to heights; housekeeping and personal protective equipment. Intervention methods were based on three approaches that are:

- behavioural change;
- goal-setting; and
- training.

The next step is to concentrate on the specific behavioural causes.

Scoring the safety performance measures
Scale consists of three columns: safe, unsafe and not seen. The reason for scoring this way is that the scoring system is weighted heavily towards unsafe behaviour, which detects the slightest improvement in the frequency of unsafe behaviour.

$$\% \text{ safe behaviour} = \frac{\text{total unsafe}}{\text{total safe + total unsafe}} \times 100$$

Procedures
The following are the procedures taken to implement this method:

1. Management briefing - a two hour briefing explaining the philosophy of utilising goal setting and feedback to improve safety performance.
2. Recruiting observers.
3. Training – content includes elements of goal setting, behaviour modification, team decision making, managing resistance from others, observational techniques and scoring of department checklist.
4. Establishing department baseline - department checklist was displayed and enlarged to A3 and displayed publicly.
5. Establishing department goals - goal setting meetings with small group over a period of 8 days.

Problems encountered

1. Resistance from line management and workforce. Resistance ranges from non-involvement to outright hostility, almost all of which was directed at the manager attending the meeting.
2. Attempts to validate safety performance measures should focus on actual concurrent safety performance and accidents, not previous accident rate.
3. Baseline data do not exhibit similar levels of safety performance prior to instigating intervention due to organisational and other contextual factor.
4. The nature of the task, sickness absenteeism and other non-safety variables may have larger impacts upon accident rates than previously recognised.

The study demonstrated that application of goal setting and feedback techniques to occupational safety, utilising a participating bottom-up approach within manufacturing industries has considerable merit. According to the authors this approach can be implemented to good effect in the construction industry. Positive effects were seen upon safe behaviour, method of working, communications and industrial relations, in addition to reductions in accident occurrence and costs.

3.4 Walker - (EPSC 1996)

The way people behave has a significant influence on the potential for accidents. The behavioural safety approach identifies, emphasises, measures and promotes 'safe;

behaviours rather than the punishment of 'at risk' behaviours. It works best when the people at the work place believe that 'safe' behaviour is the acceptable norm. There are four steps of implementation:

- identify and define critical behaviour;
- train observers to recognise and measure the occurrence of the behaviours in the workplace;
- establish a system of ongoing observation and feedback; and
- use gathered data to identify corrective actions and plans for continuous improvement.

Barriers

There are a number of barriers which may affect the implementation of the behavioural approach to safe working:

- the company culture and commitment to safety;
- plant and equipment may in itself be unsafe. This indicates poor commitment to safety;
- individuals at all levels feel threatened when being observed;
- management systems may need to be changed. Management must show support in enforcing the approach;
- payment and rewards schemes may conflict. It is possible to run schemes which reward safe behaviour, but it should be possible to achieve sufficient buy-in to eliminate the need for reward schemes; and
- disagreement on safe practice, or need for improvement.

3.5 Top – (EPSC 1996)

The measurement of behaviour is, in principle, directed at two groups:

- people in leadership positions (managers, supervisors and relevant staff); and
- people in operating positions.

People in a leadership position

The evaluation of leadership behaviour cannot normally be done through visual observation but requires interviewing the people concerned and necessary people at the receiving end. These evaluations are done using a set of criteria (questions) for leadership performance.

The quantified results of the observations that is the interviews can be used in different ways:

- for comparison with the maximum obtainable score (such as 65 out of 100);
- for comparison with the results from previous interviews of the same individual (for example 65 vs. 55); and
- for comparison with the average number obtained from a group of people in similar positions (for example 65 vs. an average of 75).

As follow-up after the observations, the results are discussed with the individual and action plan agreed to improve the individual's behaviour.

People in operating positions

The measurement of behaviours of people in operating positions can be divided into two categories:

- general behaviour observations, which is the observation of the way people behave in a more general sense while doing their work; and
- task observations, which are directed at the performance of people in the execution of specific tasks which have been identified as 'critical'.

The outcome of the generals observations can be used for comparison:

- the maximum obtainable score (such as 80 out of 100);
- the results from previous observations within the same group or department (for example 80 vs. 72); and
- for comparison with the average results obtained from observing similar groups or departments (for example 80 vs. an average of 75).

As follow-up after the general observations, the results are fed back to the group or department involved and reasons for showing undesired behaviour are discussed. An action plan is set up in order to improve behaviour.

As for the task observation, the analysis is carried out in relation to the effectiveness of training provided to the individual. From here, the need for further training, the appropriateness of the work environment and the tools, materials and any change that may have occurred since previous observations and which may necessitate a change of the task procedure will be considered.

The result of a task observation will be directed at the individual observed, in particular where it concerns individual aspects that need additional training.

4.0 SAFETY CULTURE/SAFETY CLIMATE

The following section discussed a proactive approach to measure safety culture in organisations as reported by:

- AEA Technology
- Safety Climate Survey Tool; and
- Safety Climate Assessment.

4.1 AEA Technology - (Harrison 1996)

Culture is something that pervades a whole organisation. It is intrinsic to the way individuals and managers respond and behave within a corporate framework. It manifests in the frame of mind in which personnel undertake their tasks and responsibilities and the importance they attach to achieving overall company objectives.

AEA Technology developed a safety culture assessment tool to give organisations a means of identifying the status of their own safety culture. After a wide ranging technical review, the parameters could be organised in one of the nine key sub-groups into three overall groups as in Table A3.1.

Table A3.1 – The safety culture framework (EPSR 1996)

Management and organisational factors	**Enabling activities**	**Individual factors**
• Positive organisational attributes • Management commitment to safety • Strategic flexibility • Participation and empowerment	• Reinforcement and incentives • Communication	• Individual ownership • Individual perceptions • Training

The three main areas within the safety culture framework provided the structure around which the safety culture assessment tool was developed. The management and organisational factors are assessed by a series of management interviews. The overall aim of these interviews is to check that the managers are aware of factors under their direct control that have an implication for a positive safety culture and have put a system into place to control them. The interviews also allow a comparison of how different levels of management impact upon the organisation's safety culture. The questions are open-ended type

The enabling factors are assessed by interviews designed by those responsible for training, safety and personnel issues. These interviews have been designed specifically to determine whether sufficient and suitable initiatives are in place to inform, train and motivate personnel, all of which have implications for the safety culture. The majority of the questions require 'yes/no' answers.

The individual factors are assessed by a questionnaire completed by everyone in an organisation. Its purpose is to determine individuals' attitudes, opinions and perceptions of safety. Majority of the questions require individuals to choose from options and strongly agree/ agree/disagree/strongly disagree) which best fit their response to the questions.

The components of the interviews and questionnaires are based on the 129 safety culture parameters. All three methodologies are able to provide an overall picture of the organisation's safety culture. The result of the assessment will highlight an organisation's strength and weaknesses. Recommendations are made about how to build on strengths and overcome weaknesses.

4.2 Climate Survey Tool – (HSE 1997)

The purpose of the H&S Climate Survey Tool is to promote employee involvement in health and safety by seeking people's views on some key aspects of health and safety in their organisation and then involving them in seeking improvement based on the information which emerges.

The Health and Safety Climate Survey Tool consists of

- a 71 statement employee questionnaire;
- a manual which describe a process for undertaking a survey using the questionnaire and then taking the results forward;
- a computer software which allows an organisation to customise the survey to its own terms, print the questionnaire, analyse the results in a variety of ways and print reports showing results in graphical and tabular form; and
- a software manual which gives full details on how to install and use the software

The questionnaire is designed so those respondents rate their responses to various statements on a 1-5 Likert scale, from strongly disagree to strongly agree. It is purposely designed to seek the views of managers, supervisors and members of the workforce as three discrete groups so that their results can be compared. For the purpose of this product the term workforce means people who have no subordinates, supervisor means people at the first level in the organisation who have responsibility for others, managers means anyone in the organisation above the level of supervisor.

The main trial involved some 34 locations from a range of employment sectors to some 5800 respondents. There is a case of 67 common statements and four statements which are specific to supervisors and the workforce. Statistical analysis of the data was undertaken and 10 factors, which underlie the structure, have been identified and assigned a title and they are:

- organisational commitment and communication;
- line management commitment;
- supervisor's role;
- personal role;
- work mate influence;
- competence;
- risk taking behaviour and some contributory influences;
- obstacles to safe behaviour;
- permit to work systems; and
- reporting of accident and near misses.

The Health and Safety Climate Survey Tool may provide the user with the following benefits:

- raising the profile of health and safety;
- active monitoring;
- benchmarking;
- setting agendas;
- capturing 'sensitive' information;
- working together;
- providing a baseline measure; and
- complementing audits.

The software has a modest system requirement but these will vary depending on the complexity and size of the organisation carrying out the survey. The minimum requirement is free hard disk space of 4 megabytes and 4 megabytes of RAM. The software is designed to run in Windows 3.1, Windows for Workgroups 11 or Windows 95 environments.

4.3 Safety Climate Assessment – (Loughborough University 1999)

The offshore Safety Climate Assessment technique is based on the use of multiple methods. This technique was based on information derived from literature and organisational culture and climate, as well as previous studies in offshore sector. The technique includes three methods for assessing safety climate offshore and seeks to build on current industry initiatives. The three methods are:

- attitude assessment and questionnaires;
- interviews and focus groups; and
- behavioural observational assessment.

Attitude assessment and questionnaire

In general terms, the attitude measures, or dimensions, used in this toolkit:

- organisational context;
- social environment;
- individual appreciation; and
- work environment.

Organisational context

- management commitment - perceptions of management's overt commitment to health and safety issues;
- communication - the nature and efficiency of health and safety communications within the organisation;
- priority of safety - the relative status of health and safety issues within the organisation; and
- safety rules and procedures - views on the efficacy and necessity of rules and procedures.

Social Environment

- supportive environment - The nature of the social environment at work, and the support derived from it; and
- involvement - The extent to which safety is a focus for everyone and all are involved.

Individual Appreciation

- personal priorities and need for safety - the individual's view of their own health and safety management and need to feel safe; and
- personal appreciation of risk - how individuals view the risk associated with work.

Work Environment

- physical work environment - perceptions of the nature of the physical environment.

Organisation Specific Factors

- attitudes to specific safety related systems and procedures (for example, permit to work systems) may be included as necessary.

Interviews and focus groups

There are two main reasons for conducting interviews and focus discussion groups:

- they elicit subjective meanings, and
- they permit exploration of issues not always possible using standard formatted questionnaires.

The interview/focus group structure focuses on the following areas of health and safety systems:
- co-operation;
- competence and training;
- management style;
- managing change; and
- shared values.

The five tables of questions relating to co-operation, competence and training, management style, managing change and shared values provide a structure for the interview or focus group process. Issues to bear in mind when planning interviews or focus discussion groups include:
- timing - be realistic, even a short interview will probably take about 30 minutes, a structured focus group will take a little longer;
- introduction - be sure to introduce the topic areas to be covered in the interview or discussion and explain the purpose of asking people for their views;
- taking notes - it will not be necessary to write all comments down verbatim but you should try to be as objective as possible. If the interview schedule is to be used as a focus group structure it may be better to involve a second observer to take notes; and
- group composition - it may be better to limit focus discussion group composition to those of a similar grade or standing within the organisation. Some participants may feel inhibited when in a discussion group containing their superiors.

Behavioural indicators

Behavioural indicators refer to a set of performance indicators which give some idea of how an organisation is behaving. These might include, for example, the number of planned training courses that have actually taken place. The indicators included in this section are the result of discussions with offshore safety professionals and research into good practice in other industries. There is scope for the user of this toolkit to add organisation specific indicators to the list if this will aid the monitoring process.

Behavioural indicators in offshore environments can be derived from a number of sources:

Direct Observation

- of safe and unsafe acts
- using a behavioural checklist for critical tasks

Indirect Observation

- Examination of Documentation/Compliance and Practices, including:
    - Unplanned emissions
    - Process Compliance
    - Safety inspections/tours
    - Training sessions

- Accident and incident reports
  - Accident reports
  - Near miss incidents

Assessment process

Interpreting the results of the safety climate assessment should not be done in isolation from other safety appraisal systems. When conducting a site audit at the same time as the safety climate assessment, it is important to look at the strengths and weaknesses highlighted by each exercise and examine any possible or probable links between the two.

In each of the assessment sections of the Safety Climate Assessment Toolkit, several measures are derived using the different assessment methods: A score is then computed for each of these measures (the detailed scoring of the safety climate measures is dealt with in detail in the Safety Climate Assessment Toolkit). Figure A3.7 shows how the scores derived from the climate measures can be plotted to provide a graphical representation of each dimension and an overall picture of the current state of the organisation.

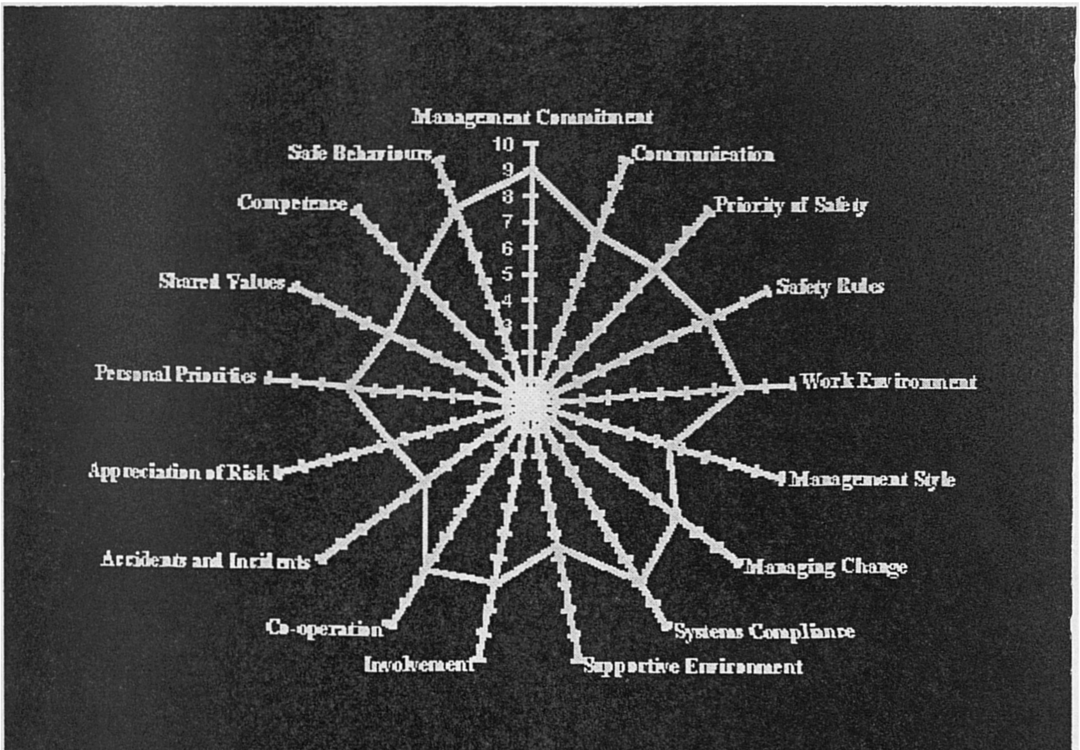

Figure A3.7 – Results radar plot (Loughborough University 1999)

Other graphs may be used to display the results of the safety climate assessment exercise. Bar charts, for example, might highlight any changes in score in a format which your organisation uses for other performance indicators. A safety climate assessment matrix can also be completed using the results to illustrate strengths and weaknesses in each of the areas and how these relate to the organisation, the work group and the individual (a score below 6 (representative of the mid point on many of the scales used) may be considered poor). An example of a matrix is shown in Table A3.3 showing strengths (denoted by a '+') and weaknesses (denoted by a '-').

Table A3.2 – Safety climate assessment matrix (Loughborough University 1999)

System Interfaces				
		Organisation/ Environment	Work group/organisation systems	Individual/group/ organisation system
METHODS	Attitude questionnaires	• Management commitment (+) • Work Environment (+)	• Supportive environment (-) • Involvement (+)	Appreciation of • Risk (-) • Personal Priorities (+)
	Focus Group/ Interviews	• Management style (-)	• *Co-operation (+)*	• *Shared value (-)*
	Direct/indirect observation	• Safety system compliance (+)	• Accidents and incidents (-)	• Safe behaviours (+)

5.0 PROACTIVE SAFETY PERFORMANCE

The following section measures the safety performance <u>on site</u> as carried out by the following:

- SPSS;
- Safety Performance Indicator ;
- EMS/SMS;
- Proactive safety factors;
- Safety performance model; and
- Safety system.

5.1 SPSS – (Kvaerner Construction UK Building 1998)

Kvaerner Construction UK Building has developed a proactive method of assessment that is called Site Safety Performance System (SSPS). Its purpose is to assist site management in the reduction of accidents on construction sites by encouraging the participation of the workforce in a system of measuring and improving site safety performance and promoting safe behaviour at work.

This system is applied to all construction contract, which exceed three months continuous duration or where it is stated in the project plan. Site safety performance is measured in several categories. The site manager will decide which of the categories are applicable to the contract and reference their implementation in the Health and Safety Plan and site induction training. Sufficient trained observers will be appointed to implement and oversee the operation of SSPS. On larger projects more than one observer may be needed. Holiday cover also has to be considered when determining observer quantities. The observer carries out formal observations at intervals not exceeding one week. Observation is done on a snap-shot basis.

Using the Safety Performance Sheets for each category, the procedure for measuring site safety performance is as follows: -

- carry out formal observations;
- score proportion of unsafe situations in each category;
- calculate raw score;
- calculate safety performance level (SPL) using equation supplied;
- calculate weekly average SPL; and
- compare SPL with target.

Once the calculations have been completed, the information should be produced in a suitable format (for example graphs) to give immediate feedback to the workforce on current site safety performance levels and comparison with the agreed targets. Feedback may be direct, involving a gathering together of the workforce or indirect by the use of site safety notice board. Good feedback is essential if the objectives of promoting awareness and persuading individuals to improve their safety-related behaviour are to be realised.

Categories that are measured are:

- PPE;
- access to heights;
- scaffolding;
- signing and guarding;
- mobile plant/equipment category;
- environmental category;
- documentation category;
- mobile access scaffold; and
- lifting operations.

5.2 Performance Indicator - (North Sea Chapter Safety 1999)

The company uses the leading Performance Indicator Matrix, which is explained as follows in Table A3.3:

Table A3.3 - Leading Performance Indicator Matrix:

Leading indicators	Areas	Estimated percentage achieved	Percentage available	Percentage outstanding
Management commitment	Compliance with Personal Safety Contract		100	
Health, Safety and Environmental Plans	Tasks achieved verses targets		100	
Safety meetings and Representatives	Safety meetings attended Representative trained		100	
Risk awareness	Risk assessment completed		100	
Training and competence	Completion of training		100	
Occupational health	Occupational health plan			
Audits and follow up	Achieved audit review Corrective actions closed		100	
Technical integrity	Operational availability of safe critical equipment		100	
			800	

Each leading indicator is explained below:

Management commitment

The objective is to demonstrate that each Manager has a 'Personal Safety Contract'. The 'Personal Safety Contract' will include commitments such as:

- specify a minimum a number of visits per month/yea;r
- lead (x) number of safety initiatives and accident investigations;
- establish a safety suggestion award scheme
- introduce a safety culture change initiative;
- participate in industry safe work groups;
- carry out cross-industry audits with contractors' personnel;
- apply accident prevention techniques at home and report findings; and
- undertake to improve personal safety habits (e.g. stop smoking).

This indicator is measured by qualifying managers' percentage compliance with their 'Personal Safety Contracts'

Health, Safety and Environmental Plans

To ensure that safety activities are planned and monitored to achieve performance improvement. This is measured by the percentage of tasks achieved versus target – measured over the annual target.

Safety meetings and Safety Representative

To help motivate employees and promote effective communication on health and safety matters. This is measured by the percentage of staff attending a properly structured safety meeting once a month.

Risk awareness

To ensure that all members of the workforce understand the concept of risk management and can apply the associated process of hazard identification, risk assessment, planning and review on a task, day-to-day basis. To measure risk assessment, percentage of the total workforce who have received formal training in workplace risk assessment process and the concept of risk management is calculated.

Training and competence
To ensure that personnel working and visitors to the site are appropriately trained and demonstrably competent and also familiar with site hazard/safety cases and local emergency procedures. This is measured by the percentage of completion of training and competence assurance against plan.

Occupational health
To raise management and workforce awareness of Occupational Health, Hygiene and Welfare. This is measured by the percentage of achievement of Occupational Health plan.

Audits and follow-up
To ensure that adequate arrangements for audit and review have been established, implemented and followed up. To measure this, the percentage of audits that have been achieved against the 'Audit Review Plan' and 'Corrective Action' formally closed-out against an agreed time-scale is calculated.

Technical integrity
To raise awareness of safety critical systems and safety critical elements along with the need to monitor and maintain those systems with their performance standards. The percentage level of compliance of the systems and elements against their respective performance standards as observed by an independent verifier is calculated.

5.3 SMS – (Asheidu et al 1996)

Improving safety performance consists of three areas namely: development of a management system; a hazard management process; and rigorous auditing of work sites.

- **Safety management**

A major programme for developing a contractor's system in line with the principles of Enhanced Safety Management (ESM) directly linked with the model Safety Management System (SMS) was developed. ESM is the foundation for safety management, providing an objective approach for an effective management of safety in any establishment. ESM comprises of 12 principles as in Figure A3.8.

Enhanced Safety Management | **Safety Management System Model**

Management commitment
Sound safety policy
Targets and objectives

Line management responsibility
Competent safety advisers
Effective training

Safety standards

Effective planning
Techniques to measure performance
Effective motivation & communication

Audit of standards/practices
Accident investigation

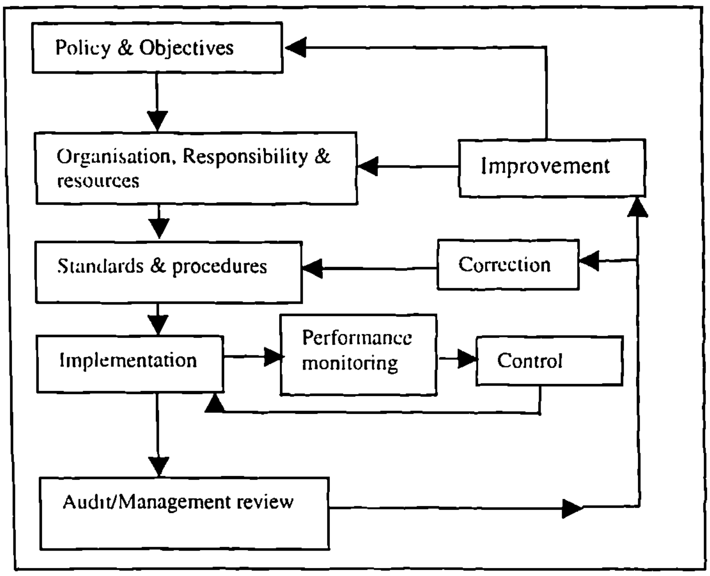

Figure A3.8– Structure of ESM linkage with SMS (Asheidu R.I 1996)

Implementation of safety management

The system is deployed in phases to review a contractor's own system versus ESM and a score is given. A high score indicates the contractors system meets the ESM requirement. The contractors with low scores must improve their own systems until they reach the ESM standard.

Hazard Management

An enhancement of the Unsafe Act Audit (UAA) technique was adapted. Since UAA suffered from a weak follow-up and close-up mechanism as well as superficial application based on the 'need to fill quotas'. Therefore a hazard management procedure that is linked with the overall system was developed and renamed hazard management inspection.

Implementation of hazard management

During inspection (whether routine or spot check), a standard reporting and action plan is in place for every hazard identified with particular emphasis on 'action to prevent recurrence'. The relevant company contract holder is responsible for maintaining a hazard management register for the project and must demonstrate close-out action. The system is daily audited on site, the supervisory staff review the registers weekly and a monthly analysis of the hazards, for trends, is carried out by the company safety co-ordinator. Training on the hazard management procedures is carried out for both company and contractor staff. A monthly presentation to the management of hazard returns is being carried out. As a result of this implementation; the involvement of the contractors in hazard management activities has increased from 18% (1993) to 53% (1995).

Rigorous audit
Auditing and feedback represent a vital link in the plan-do-check-feedback loop, by helping to ensure compliance with relevant procedures, and activate corrective actions as appropriate.

Implementation of rigorous audit
Carry out weekly site audits by cross-departmental inspection teams. Continuous checks that recommendations made in the facilities and Lost Time Injury (LTI) incident reports for the past two years are reviewed. In addition special Safety Inspectors are employed to verify the actual implementation and compliance status and feedback their findings to management team.

5.4 Proactive safety factors – (Jaselskis E.J. 1996)

Jaselskis carried out a study to identify the necessary factors to achieve successful safety performance. He identified eight factors necessary to achieve outstanding project safety performance and they are as follows:

- upper management attitude;
- project management team turnover;
- safety representative;
- safety meetings with supervisors;
- specialist-contractors;
- informal meetings with supervisors;
- site safety inspections; and
- worker safety performance fines.

Upper management attitude
Strengthen upper management attitude toward the importance of safety. Projects that achieved outstanding project stature had strong upper management support compared to below average projects where management support was weaker.

Project management team turnover
Reduce project-management team turnover as much as possible. Outstanding projects experienced lower turnover rates compared to average and below average projects. This suggests that team stability plays a role in achieving better safety performance.

Time devoted to safety by field safety representative
Field safety representatives should spend 30-40% of their time on safety issues. Expending less time may compromise the project safety outcome.

Number of formal safety meetings with supervisors
Increase the number of formal safety meetings with supervisors to one per week. Outstanding projects averaged 3.5 meetings per month compare to 2.6 for below average and average projects.

Speciality contractor
Increase the number of formal meetings with speciality contractor to three per month. Below average projects average about 1.8 meetings per month.

Number of informal safety meeting with supervisors
Increase the number of informal safety meeting to 6 per month. Below average and average experience 4 meetings per month.

Site safety inspection
Increase informal site safety inspection to four per week. Below average and average projects averaged approximately 1.5 informal inspections per week.

Worker safety performance fines
Consider minimising the size of the fine for workers who exhibit poor safety performance. Outstanding projects fined workers an average of $13 per violation compare to $82 for below average and average projects. This suggests that workers respond better to positive approaches when trying to comply with company safety policies.

Projects were classified using the recordable incidence rate and a subjective rating approach involving three distinct project outcome categories: below average, average and outstanding projects.

5.5 Safety performance model – (Cameroon et al 1999)

Cameroon developed a safety performance model where individuals are influenced by a continuous interaction between their attitude, behaviour and the situation in which they find themselves (Figure A3.9).

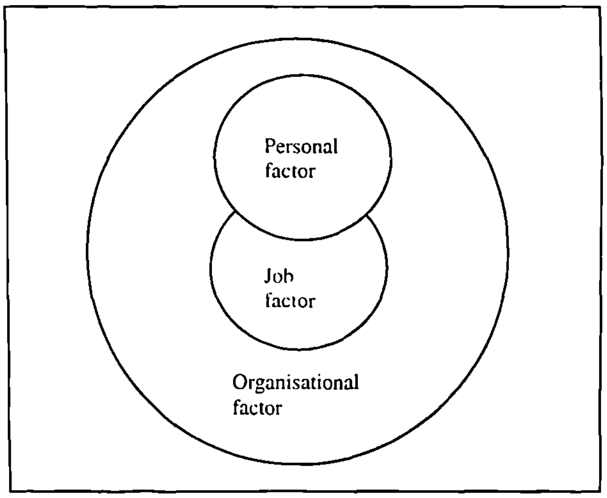

Figure A3.9 – HSE human factor influence model (adapted from Cameroon et al 1999)

The model represents a theoretical framework, which requires development to form a practical framework for the measurement of attitudinal, behavioural and organisation factors, which influence safety (Figure A3.10).

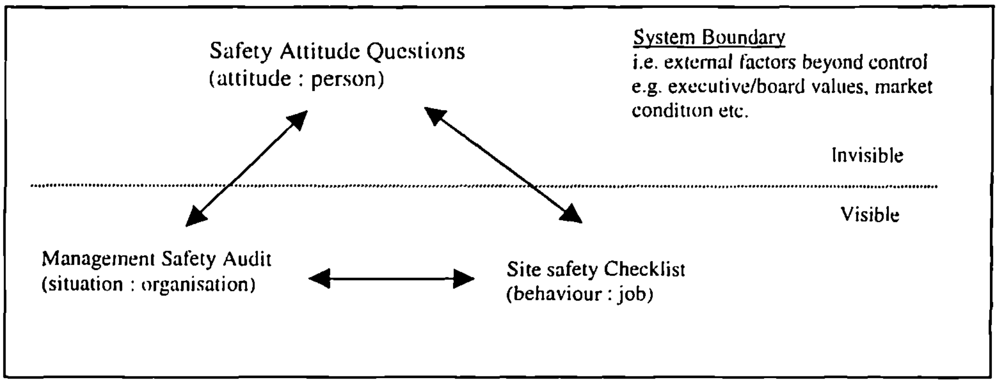

Figure A3.10 – Construction safety culture influence model (adapted Cameroon et al)

The management safety audit, physical safety checklist and safety attitude questions represent leading indicators of safety performance. Attitude may be measured via a questionnaire (safety climate instrument), behaviour may be measured via an inventory of site conditions (checklist for site hazards) and situation may be measured via a system audit (safety management audit). This model offers a framework within which indicators of safety culture may be measured for performance monitoring.

Measurement of employee safety attitude: safety climate questionnaire
This instrument attempts to evaluate employee perceptions of this work environments, by the use of questionnaires comprising of multiple choice questions related to management attitude towards safety, management actions towards safety, importance of safety training, status of safety officer, safety committee, perceived level of risk. and effect of workplace.

Limitation of this approach is asking people their belief may not be a valid predicator of their behaviour. Attitudes are often an expression of 'how we would like ourselves behave'.

Measurement of operatives safe behaviour: site safety checklist
These interventions measure the frequency of observed safe behaviour. This approach is a direct measurement of key unsafe behaviours and situations are more reliable indicators of safety performance. This approach records many more events that could be obtained by the use of accident statistics. The construction behavioural checklist measures the presence of safety, whereas accident data measures the absence of safety. This approach is also targeted at visible behaviour and situation.

The checklist invariably comprises of several categories:
- housekeeping;
- access-to-height;
- scaffolding;
- PPE;
- site order; and
- site access.

Measurement of organisational safety factors: management audit
The importance of management control has come to the fore of the corporate agenda in recent years. This philosophy has recently been extended to safety by the introduction of a British Standard for safety management system known as BS 8800.

This approach has been criticised by the users for using superficial questions, which fail to evaluate safety effort and therefore do not represent a true picture of management's ongoing support for safety. Due to this reason, Cameroon developed a Safety Management Behavioural Audit for the construction industry. This approach measures seven key aspects of management safety behavioural each month that are:

- induction;
- committee;
- sub-contractors;
- safety advisers;
- tool-box training;
- records; and
- operative rating.

This audit is used along with the management techniques of goal-setting and posted feedback to motivate managers to continuously improve their safety performance audit score. From here the Project Safety Culture Index can be calculated (Figure A3.11).

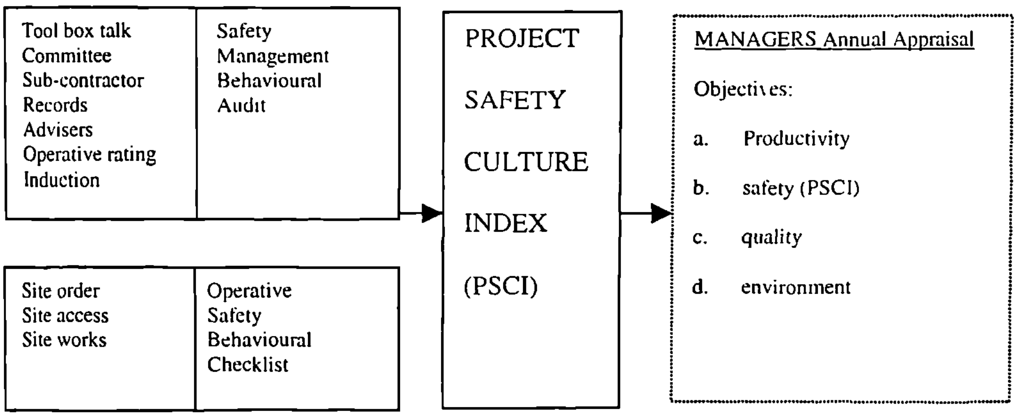

Figure A3.11 – Total Safety Management: An Integrated "Project Safety Culture Index" (adapted from Cameroon 1999)

5.6 Safety system – (Fitts 1994)

The objective of a safety system should be to provide a healthy working environment where risk of injury and illness is as low as reasonably practical (Figure A3.12).

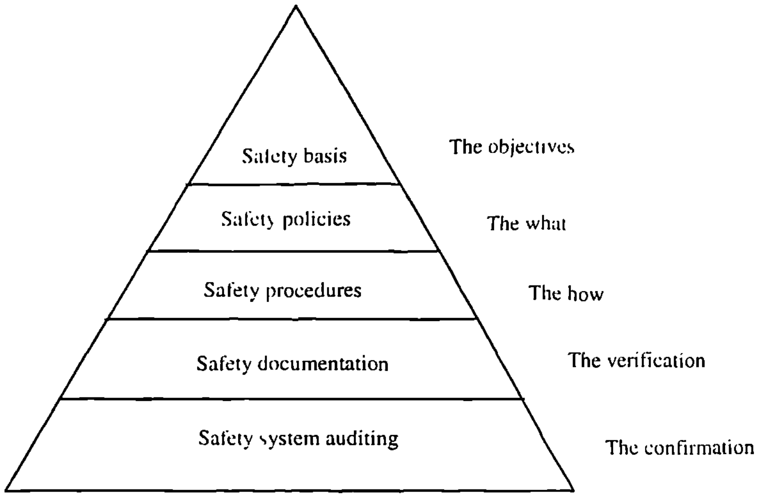

Figure A3.12 – Safety Management System (Fitts 1994)

The objective can be defined in the form of a company safety policy statement, which should be posted, displayed and made available for review by any personnel. Policies define safety standards, what will be done, how often it will be done and by whom. Procedures describe in greater detail how the standard will be achieved. Procedures should provide enough detail to describe the expectations of management yet remain flexible enough to allow persons working within the system the latitude to be creative, improve the operation and think for themselves. Documentation furnishes a recorded account of a specific standard. The system should define what elements of the safety system require documented evidence and provide detailed guidance on how to complete the documents. Auditing a safety management system to a well-defined audit plan will provide confidence that the system is functioning on a continuous basis as intended.

The system is defined in two sets of manuals. A corporate manual applicable company wide and one or more manuals defining regional or site-specific policies and procedures. The key to a successful safety management system is the involvement of people. Programmes that involve personnel stimulate participation and keep a safety system from collecting dust on a shelf. The key to involvement is for management to transfer ownership of the system to the workforce. Ownership must start with an understanding of the system, which is achieved through safety orientations and subsequent safety training in the policies, procedures and programmes that comprise the system.

Safety communication will assist in maintaining interest and enthusiasm in the safety system. Safety observations should be a routine activity performed by everyone in the organisation. The more frequent the observations the higher the level of safety awareness and the lower the number of potential safety in the working environment.

Safety system assessment

Comprehensive safety assessment or audits, conducted at appropriate intervals, will promote the continuous function of a safety system. Observation should be the final point of an assessment to verify actual implementation and effectiveness of system policies and procedures. The assessment should include interviews to verify personnel knowledge of the system and a review of documentation to provide confidence that the system is functioning as intended on a common basis.

If there are any variances between what is occurring and what is defined by the standard: corrective actions will be required. Corrective action can take two forms:
1. plans are formulated to bring performance up to the defined standard; and
2. the standard can be rewritten to better reflect what is actually occurring on the shop floor.

Either alternative will promote ownership in the system and increase the probability that the standard will be met in the future.

A safety management system must be clearly defined, measurable, controllable and capable of improvement. The workforce must know what is expected their management, take pride in the achievement of measurable objectives and have ownership of the system in which they participate.

5.7 OHS performance measurement – (NOHSC 1999)

The National Occupational Health and Safety Commission (NOHSC) of Australia had developed positive performance indicators for construction industry. The key levels of good occupational, health and safety (OHS) performance are:
- senior management;
- successful marketing of OHS;
- OHS obligations to employees and the public;
- external enforcement; and
- cost reduction associated with poor OHS (e.g. insurance premiums, lost time)

Strategies that were taken by the OHS were:
- leadership in OHS;
- design and planning initiatives;
- methods for consultation, communication and participation;
- management of sub-contractors;
- system and process to manage OHS;
- training and education initiatives;
- risk management and control of hazards; and
- auditing procedures.

NOHSC had developed a list of positive performance indicators for the use in construction industry. These positive performance will assist the industry to assess the effectiveness of OHS improvements strategies and could be used either within an enterprise or across enterprises. The list is based on the distillation of results of the sixteen case studies across all sectors of the construction industry – commercial, civil, heavy engineering and domestic construction.

The indicators were grouped under five main headings:
- planning and design;
- management process;
- risk management;
- psycho-social working environment; and

- monitoring.

This list of indicators was presented to the enterprise to refine the indicators that best suits the organisations. The best approach to developing performance indicators in the construction industry is to choose from the list above and use workshops to develop indicators of OHS specific for the enterprise or projects.

This approach is tailored to what each enterprise or project needs.

6.0 SAFETY TRAINING SYSTEMS

This section discussed about the Safety Training Observation Programme (STOP).

The Safety Training Observation Programme (STOP) was developed in the mid-1960's by DuPont, a world leader in industrial safety. Since then DuPont has become the cornerstone for establishing behaviour based safety system in many companies. STOP is built on Heinrich's principles of accident causation. However, DuPont suggests an even larger number (96%) of lost workdays (compared to 88% by Heinrich) and restricted workday cases are caused by unsafe acts of people and employee created unsafe conditions.

The objective of STOP is to train field supervisors to become skilled observers of people's work practices, focusing on unsafe acts of people to eliminate injuries. It teaches line managers effective people skills so they may communicate with subordinates in a positive, non-threatening manner to help employees understand why their unsafe acts are hazardous. Additionally STOP trains employees to develop a keen sense of safety awareness and encourages them to think before they act, both on and off the job. STOP is built on six principles that are:

- all accidents can be prevented;
- safety is a line management responsibility;
- all operating exposures can be reasonably safeguarded;
- safety training is also a line management responsibility;
- safety is a condition of employment; and
- safety is good business.

The STOP process encourages supervisors and other employees to apply accident prevention techniques using a five-step cycle. The cycle is defined by the following terms: DECIDE-STOP-OBSERVE-ACT-REPORT (Figure A3.13). The cycle begins with a commitment by observers to focus their attention on operational safety (DECIDE-STOP). The third step (OBSERVE) encourage employees to look for and recognise unsafe behaviour in the work place. Once an unsafe work habit is identified, it is essential that the observer takes immediate corrective action to prevent injury, as well as action to prevent recurrence of the unsafe behaviour (ACT). The final step (REPORT) requires an observer to record what was observed and what action was taken to prevent potential injury. This record is entered on pre-printed cards.

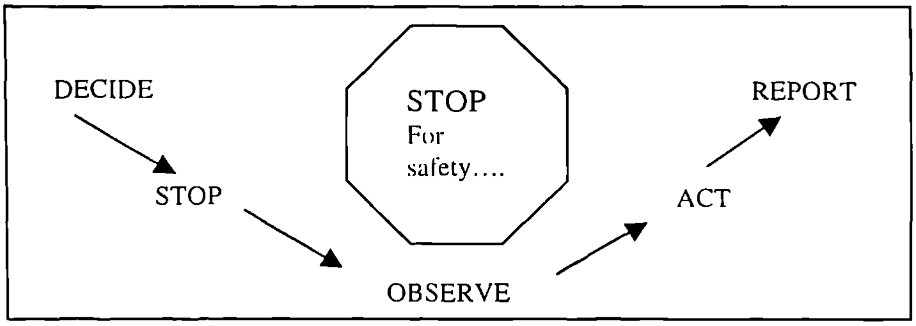

Figure A3.13 – STOP observation cycle (Hubler 1995)

The STOP incidence rates are a more accurate barometer of safety performance for two reasons. First, because they are taken from a larger sample data base of potential exposures (e.g. STOP observations per 200,000 or one million man-hours) which are statistically more valid than smaller pools of recordable injuries. Secondly, because they measure upstream activities or leading indicators rather than strictly the system failures reflected by injury.

7.0 REACTIVE MEASURES

The most common measure of safety performance is the reactive measures. The following discussion focus on the reactive measures as discussed by:

- classification of reactive measures;
- GUARD;
- OCCAR; and
- TRIPOD

7.1 Classification of reactive measures – (Laufer et al 1986)

The study examined the effectiveness and the extent to which the various safety measuring methods at construction sites are used. The purpose of safety measurement in this research was:

1. evaluation of the safety programme effectiveness at the site;
2. determination of the reasons of success or failure; and
3. location and identification of problem areas and determination of the level of remedial effort to be applied.

Measuring methods are characterised primarily by the manner in which they relate to the criteria of safety effectiveness, the events measured and the method of data collection. The frequency element of the undesirable event usually splits up into four categories:

1. Lost day cases – cases which bring absence from work;
2. Doctor's cases – non-lost workday cases that are attended by a doctor;
3. First aid cases – non-lost workday cases requiring only first aid treatment; and
4. No-injury cases – accidents not resulting in personal injury but including property damage or productivity disruption.

Table A3.4 presents the classification of the safety measurement methods employed in this study. Both the post accident and pre-accident data were used to measure safety performance.

Table A3.4 – Classification of safety performance (Laufer 1986)

Time of measurement	Criterion of safety effectiveness	Data collection method	Performance measure	Frequency of unit measured unit	Severity of measured unit
Post-accident	Frequency of undesirable events	Secondary data	Lost day cases Doctor's cases First-aid cases No-injury cases	Very low Low Medium High	High Medium Low Low
	Severity of undesirable events	Secondary data	Days lost Cost of accidents	Low Low-medium	High High
Pre-accident	Undesirable practices	Observation	Safety climate	Very high Very high	Very low Very low
		Questionnaires, interviews	Critical incidents	High	Low

Participants were presented with a description of safety performance measurement techniques and the attributes under consideration. They were asked to grade each measure with regard to being (1) efficient (2) reliable (3) valid (4) able to serve as a diagnostic tool.

The conclusion was that for the successful safety performance measuring methods at construction sites, the simultaneous employment of a number of measuring methods is required. The most effective and at the same time the most widely used have been found to be lost day cases, doctor's cases and cost of accident. No injury cases were least effective and least in use. Proactive methods were found to be effective as far as their validity and diagnostic capacity extends, though their efficiency and reliability were found to be low.

7.2 GUARD – (Haines. et al 1991)

Sarawak Shell have followed an enhanced safety management programme since the early 1980's and made significant improvements in their safety record. A leading indicator of safety performance is Lost Time Injury (LTI) frequency. Soon they realised that retaining LTI as the basis for key safety performance indicators generates negative effects. So a more sensitive statistical measure of safety performance is developed.

Accident statistic are not always as good as reporting and there are inevitably two ways to reach any targets set by management: the legitimate way is to manage things so as not to have the accidents (high targets) while the undesirable way is to cover up (low target). Figure A3.14 shows the possible undesirable methods, which can be used to reduce the number of accidents in different classes of severity. The more emphasis placed on meeting low statistical targets, the greater will be the temptation to use the same methods of concealment. Small incidents seen by few people are easy to conceal. For this reason low targets for such things as first aid injuries or near misses are not set because they would simply discourage reporting and perhaps prevent employees seeking proper medical treatment.

They have turned to look at the possibilities for using the information gathered when accidents and near misses are investigated to generate not only a useful measure of safety performance but also a target that would not encourage undesirable behaviour with regard to reporting. Two pieces of information related to every accident or near miss were considered; the potential for injury and the standard underlying cause category. An estimate is made on a standard scale of how severe the accident or near miss could have been and how many people might have been affected. Standards are based on research work done for Shell on accident causes cause were introduced with the new Group Unified Accident Reporting Database (GUARD) incident reporting system.

INDICATOR	LOW TARGET	HIGH TARGET
DEATH RATE	• Cause of death modified to natural causes. • Victim remove from site to die	HIGH TARGET NOT APPLICABLE
LTI RATE	• Downgrading of severity • Cover up by taking leave • Cover up by sudden dismissal	
RECORDABLE INJURY RATE	• Self treatment of injuries • Down grading to first aid • Concealment of injuries	
ALL INJURIES INCLUDING FIRST AID	• Self treatment of minor injuries	• Inclusion of out of work injuries • Multiple reporting of same ailment • Ill-health reported as injury
ALL INJURIES PLUS EQUIPMENT DAMAGE	• Damage ignored and not reported • Damage repaired clandestinely	• Reporting of trivial events
ALL ACCIDENTS AND NEAR MISSES	• Near misses ignored	• Events fabricated • Reporting of trivial events

Figure A3.14 – Possible undesirable behaviour induced by different safety target (adapted from Haines 1991).

In order to encourage full reporting of all incidents any performance measure derived from either accident potential or standard underlying causes should not be amenable to excessively undesirable manipulation when it comes to reporting. Table A3.15 shows a number of possible statistical measures based on both high and low targets. The problem of adopting high targets in order to encourage minor accident and near miss reporting is that this is seen as incompatible with the target of minimising deaths and LTIs. In Figure A3.15 however the target of maximising the number of potential serious injuries relative to the actual is consistent with low LTI/death targets and does not encourage any particular undesirable misreporting.

It is said this approach is extremely valuable for it encourages thorough investigation. This approach needs quality and completeness of accident reporting and discourages under reporting.

ALTERNATIVE TARGET	LOW TARGET	HIGH TARGET
POTENTIAL DEATH OR SERIOUS INJURY FREQUENCY	• Underestimation of risk of serious consequences • Under reporting of potentially serious incidents	• Over estimation of potential • Under reporting if feedback from management is negative
POTENTIAL MINOR, MAJOR AND FATAL INJURY FREQUENCY	• Underestimation of potential consequences in general • Under reporting of incidents	• Over estimation of potential injury consequences • Reporting of trivial events
NO EXCESSIVE OCCURRENCE OF ANY SPECIFIC UNDERLYING CAUSE TYPE	• Under reporting of accidents with prevalent underlying cause type • Bias in deciding underlying cause • Deliberate facilitation of underlying cause type	NOT APPLICABLE
KEY UNDERLYING CAUSE TYPE TO BE IDENTIFIED	NOT APPLICABLE	• Bias towards perceived most prevalent underlying cause

Figure A3.15 – Possible undesirable behaviour induced by alternative safety performance targets (adapted from Haines 1991)

7.3 OCCAR – (Azambre 1991)

Occupational Accident Analysis and Reporting System (OCCAR) is a computerised system used by those responsible for any activity on sites to identify the origin of any accident/incident when it occur and the chains of events leading to the accident/incident. Azambre divides the origins of accidents is divided into the following:

- human factors;
- procedures factors; and
- technical factors.

According to Azambre the predominant cause of accidents is the human factor, which contributes towards at least 80% of accidents or hazardous events. The human factor is defined as a person who, when working on a site, becomes directly or indirectly involved in the accident/hazardous.

Procedural factors cover procedures and instructions that are not suitable or adequate for the work being carried out. Work may be described and defined in general and specific documents, which include all safety aspects of the job to be carried out. The procedural factor contributes towards 80% of accident or hazardous events. Technical factors cover design errors and material deficiencies. A design error can be caused by incorrect calculations, process conditions which do not apply to designed operating conditions or specification which are not suitable for the equipment duty. Material deficiency relates to a hidden or unknown fault in the raw material itself. The technical factor contributes towards about 10% of accidents or hazardous events.

The OCCAR system allows the information to be processed, followed by issuing of a detailed breakdown of the causes of accidents and incidents (Figure A3.16). OCCAR process all data received and can provide a permanent record of operating company safety performance. The investigation is carried out on site by a minimum of two people, one safety officer and a supervisor at the site. Investigation commences as soon as practicable after an accident or incident had occurred. Once the information is gathered, it is transferred into a diskette. It takes half a day for qualified personnel to become familiar with the OCCAR programme.

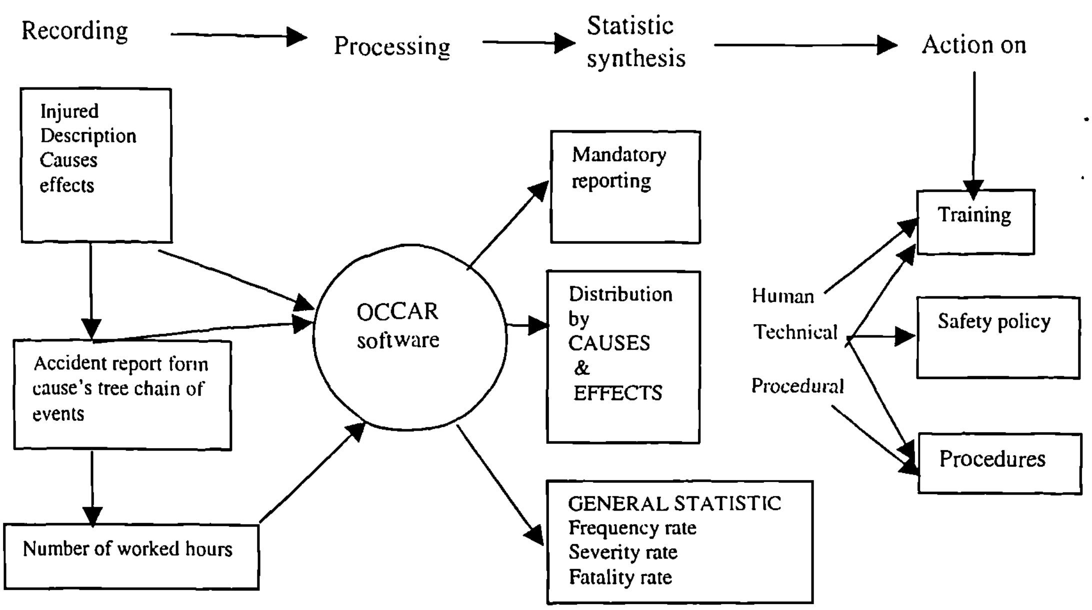

Figure A3.16– Occupational Accidents Analysis & Reporting (Azambre 1991)

This programme has proved to be successful in identifying the causes of accidents on sites and also methods of prevention are defined more clearly to avoid any repetitive accident/incident.

7.4 TRIPOD – (Wagenaar 1997)

TRIPOD put forward by Wagenaar and Reason of Manchester University basically states that all accidents follow a basic scenario with the following stages ordered with respect to time (Figure A3.18).

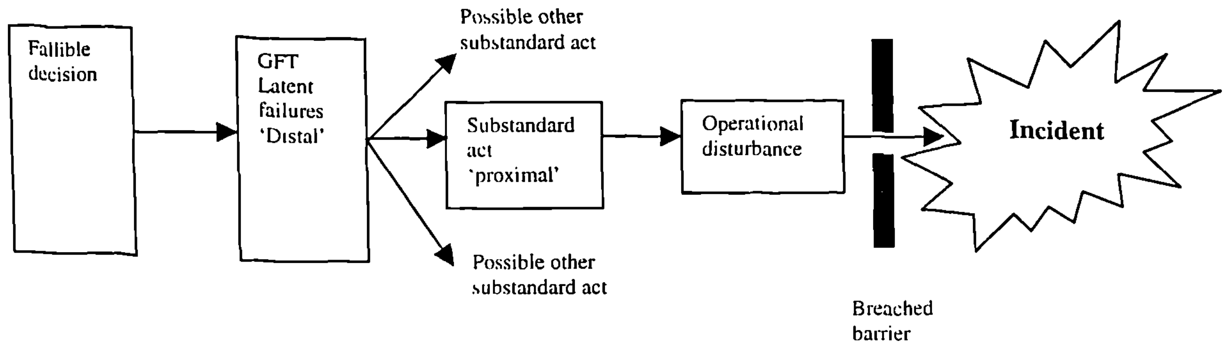

Figure A3.18 – The TRIPOD accident causation model (Wagenaar 1997)

The TRIPOD accident causation model usually contains four stages that are:
1. What people did?
2. How this cause disturbance?
3. How the barriers gave way?
4. How it all ended in accident?

Deficiencies in the working situations are called General failure type (GFTs): TRIPOD defines eleven of them:
1. design;
2. hardware;
3. procedures;
4. error enforcing conditions;
5. housekeeping;
6. training;
7. incompatible goals;
8. communications;
9. organisation;
10. maintenance management; and
11. defences.

The objective of a TRIPOD analysis is to procedure a profile of the extent to which the eleven GFTs are present in the organisation. This could be done in two ways either proactive ways through questionnaires, or reactive ways through accident analysis. GFTs are like diseases; one cannot see them directly, but only through their symptoms. In an accident investigation the symptoms of GFTs are observed events that constitute the accident scenarios.

8.0 BENCHMARKING

This section discussed the approach adopted by the European Construction Institute (ECI) to benchmark safety performance.

The definition of benchmarking adopted by the ECI is a systematic process for measuring one's performance against results from recognised leaders for the purpose of determining best practices that lead to superior performance when adopted and utilised. The objectives of benchmarking is to assist participants to:

- objectively compare their performance against others;
- provide an indication of how to improve their performance;
- quantify the use and value identified good practices; and
- identify industry norms and trends.

Benchmarking adopted 11 key safety elements in its approach and they are:

1. adopt a 'zero injury' philosophy,
2. establish specific contract safety requirements,
3. recognise quality of effort is more important than time spent,
4. understand the high cost of worker injury,
5. recognise the benefits from considering constructability,
6. conduct a safety self assessment,
7. ensure owner is a participant,
8. ensure all parties employ relevant competent staff,
9. ensure subcontractors are active participants, and
10. success in eliminating accidents is not guaranteed.

To achieve the maximum potential benefits, adherence to a recognised formal safety management system is essential. The following are the recommendation made by ECI in their safety techniques:

1. Each project has a written site-specific safety plan, to include as minimum
   - management safety policy statement;
   - safety goals and objectives and methods of measuring effectiveness;
   - outline of responsibilities for managers, supervisors, safety representatives and craft workers;
   - procedures for safety activities;
   - defined safety structure;
   - defined competency requirements for staff at appropriate levels; and
   - specific measures for dealing with areas of significant risk.

2. *Each project has a written site-specific* emergency plan
   - identify the different types of foreseeable emergency plan; and
   - specify procedures to follow in case of an emergency and responsibilities for action.

3. Each project has a nominated site safety supervisor who's experience is commensurate with the size of the project
   - be available full time;
   - ensure a regular safety inspections and audits;
   - ensure accurate record keeping; and

- have ready access to site manager.

4. A written safety incentive programme is in place for hourly paid craft employees, based upon positive actions
    - be in form of informal recognition or formal, e.g. lunches, monetary award; and
    - make part of evaluation process for bonuses.

5. Toolbox safety meeting
    - attendance is mandatory;
    - the project manager, superintendent and/or safety representative regularly attends to show support for safety; and
    - The meetings are focused and not overlong.

6. Company policy for substance abuse which should make the following points
    - all staff should be aware of it;
    - it offers a supportive approach, viewing such problems as medical;
    - it provides health education on the dangers of excessive alcohol consumption and drug abuse; and
    - employees are encouraged to seek help before a problem arise at work.

7. Accidents always formally investigated by a competent person
    - corrective action to be taken as soon as possible after investigation is complete; and
    - reports of investigation distributed and communicated to all employees to avoid re-occurrence.

8. Near misses always formally investigated by competent person
    - corrective action to be taken as soon as possible;
    - all employees regularly advised of near misses to avoid reoccurrence; and
    - employees are made aware of the benefits of reporting.

9. Accidents reviewed by senior management
    - basic cause of accidents need to be determined;
    - information to be shared with other job sites; and
    - ensure follow-up action taken.

10. Safety is high priority topic at all pre-construction and construction meetings

11. Safety records and validated competencies are criteria for contractor/sub-contractor selection

12. Pre-task planning for safety is carried out by contractor foreman
    - use checklists to ensure all exposures considered;
    - necessary equipment training provided; appropriate protective equipment provided; and
    - evidence of such available for inspection.

13. Job site – specific orientation is conducted for new contractor and sub-contractor employees, to address as a minimum
    - clarification of safety responsibilities for contractor, sub-contractor employees and all construction site personnel, including visitors;
    - safety expectations of employees;
    - explanation of company safety rules;
    - location of first aid facilities and how to be utilised;
    - procedures for reporting accidents and injuries;
    - information on tool-box talk meetings;
    - use of PPE; and
    - procedures for reporting unsafe acts or conditions.

14. Regular formal safety audits to be undertaken following a recognised process. Results to be quickly fed back into the project team and any recommendations or observations to be implemented quickly.

The owner and contractors are required to answer a series of questions which requires only a 'yes' or 'no' answer or a scaling response. From here a safe Practice Use Index is calculated as follows:

Safe Practice Use Index

$$= \frac{\Sigma \text{ of score for all answers (maximum score is 16 for 16 questions)}}{4.6 \text{ (to scale to 1-10 point range)}}$$

Safety performance is measured in terms of Recordable Incident rate (RIR)* and Lost Workday Case Incident Rate (LWCIR)**. The records show that companies with low Safe Practice Use Index suffer higher RIRs and LWCIRs.

*Recordable Incident Rate (RIR)

$$= \frac{\Sigma \text{ number of recordable cases x 200,000}}{\Sigma \text{ Site work hours}}$$

** Lost Workday Case Incident rate (LWCIR)

$$= \frac{\Sigma \text{ number of lost workday cases x 200,000}}{\Sigma \text{ Site work hours}}$$

APPENDIX 4– CD ROM VERSION OF SPMT

APPENDIX 4

CD ROM VERSION OF SPMT

A CD ROM version of SPMT is attached with the thesis. There are three files in the CD and they are:

- Read me in Rich Text Format
- Score Matrix in MS Excel
- SPMT in MS Access

To understand how to operate SPMT effectively, please read the READ ME file first. The CD ROM version will only enable the user to 'read only' all the files.

APPENDIX 5.1 – SURVEY I QUESTIONNAIRES

METHODOLOGY TO DEVELOP A PROACTIVE SAFETY PERFORMANCE MEASUREMENT TECHNIQUE (SPMT) FOR CONSTRUCTION SITES

An Industrial Survey in Current Practices

"If you don't keep the score - you are only practising". Measurement of safety performance is essential. Traditional methods of relying on post-accident data or accident statistics do not show how accidents occur or how to reduce the number of injuries. Basically only incidences that are recorded are considered. Therefore, it is timely to move the industry from purely a reactive response towards a more proactive approach to the improvement of safety performance.

This work forms part of Loughborough University Health & Safety Management research programme co-ordinated by Alistair Gibb. The aim is to develop a single measurement tool to measure safety performance on construction sites. To achieve the aim, the research objectives are:-

1. To identify realistic and measurable proactive factors and sub-factors that affect safety performance on site.
2. To develop and test the safety performance measurement tool (SPMT) that :-
   - will be able to identify problem areas
   - will allow a more focused remedial effort to be applied
   - will evaluate over time the degree of progress or retrogression of safety performance on site
   - will be a benchmark for future measurement

The first step in the research programme is to study the current practices. Hence the enclosed questionnaire was prepared to collect the actual facts from the industry and to model actual practices in real terms. The questionnaire is divided into two main sections. Section A asks for general information while Section B asks for the ranking of the factors and sub-factors that influence safety performance on site. The data collected in the survey will be treated as **confidential**.

We would be grateful if you could spare a few minutes to fill the questionnaire and post to us in the self addressed envelope enclosed ASAP to the address shown below:

Department of Civil and Building Engineering
Loughborough University
Loughborough, Leics. LE11 3TU

Attn:	**Mr Alistair Gibb**	**Miss R.K.Ahmad**
tel	01509 223097	01509 263171 ext 4133
fax	01509 223981	
e-mail	A.G.Gibb@lboro.ac.uk	R.K-Ahmad@lboro.ac.uk

Do you want a summary of the research findings?
Please circle **Yes** **No**

Your assistance in completing the questionnaire is very much appreciated. Thank you.

1.0 SECTION A - GENERAL INFORMATION

1.1 Company name

....

1.2 Company address

....
....
....

1.3 Your position *(please tick the box that most closely describe your function)*

a. **Principal Contractor**
- Head Office-based Safety Director / Manager ☐
- Site-based Safety Manager/Officer ☐
- Head Office-based Project Manager ☐
- Site-based Manager ☐
- Site Supervisor ☐
- Others (please state)................................ ☐

b. **(Sub) Contractor**
- Head Office-based Safety Director / Manager ☐
- Site-based Safety Manager/Officer ☐
- Site-based Manager ☐
- Site Supervisor ☐
- Others (please state)................................ ☐

c. **Workforce** ☐

1.4 Length of time in the industry *(please tick the appropriate box)*
1.5

a.	Less than 2 years	☐	b.	Between 2 - 4 years	☐
c.	Between 4 - 6 years	☐	d.	Between 6 - 8 years	☐
e.	Between 8 - 10 years	☐	f.	More than 10 years	☐

1.5 Construction sector where experience gained
(please tick appropriate box)

a. All engineering construction only ☐

b. Mainly engineering construction but some civil & building construction ☐

c. Mainly building & civil construction but some engineering construction ☐

d. All civil & building construction work ☐

S

2.0 SECTION B

This section is to establish the relative importance of the factors and sub-factors contributing to improve safety performance

For all questions, please score on a scale of 1-5 the effectiveness of the following techniques for improving safety on site.

Where,

- 5 = Very important
- 4 = Important
- 3 = Average
- 2 = Less important
- 1 = Not important

N.B. Each score can be use more than once

The techniques are grouped to cover different aspects

2.1 Techniques used by head office-based management

No	Sub-factors	Ranking
2.1.1	Carry out safety audits	
2.1.2	Provide up-to-date safety documentation	
2.1.3	Hazard analysis during the design & planning stage	
2.1.4	Set procedures for reporting incidents/accidents	
2.1.5	Set procedures for reporting near misses	
2.1.6	Short & long term safety budget	
2.1.7	Others (please state)	

2.2 Techniques used by site-based line management

No	Sub-factors	Ranking
2.2.1	Providing useful safety document	
2.2.2	Displaying safety policy	
2.2.3	Full time safety representative	
2.2.4	Consistently motivating personnel on site	
2.2.6	Frequent meetings with supervisors	
2.2.7	Frequent meetings with sub-contractors & suppliers	
2.2.8	Selection of sub-contractors & suppliers	
2.2.9	Others (please state)	

2.3 Techniques used by site supervisors (supervisor, foreman, ganger)

No	Sub-factors	Ranking
2.3.1	Formal inspection & checking	
2.3.2	Informal inspection & checking	
2.3.3	Regular toolbox talk	
2.3.4	Incident reviews and reporting	
2.3.5	Pre-task awareness talk	
2.3.6	Others (please state)	

2.4 Engineering control

No	Sub-factors	Ranking
2.4.1	Carrying out risk analysis and method statement for hazardous tasks	
2.4.2	Full knowledge of installation process	
2.4.3	Full knowledge of maintenance & repairs	
2.4.4	Understanding of the work procedural & relevant standards	
2.4.5	Obtaining permission & permit to work before starting work	
2.4.6	Ensuring all machinery & equipment in good working condition	
2.4.7	Others (please state)	

2.5 Housekeeping

No	Sub-factors	Ranking
2.5.1	Good storage practice	
2.5.2	Proper material handling	
2.5.3	Hazard identification on hazardous material	
2.5.4	Hazardous material management	
2.5.5	Proper waste management	
2.5.6	Others (please state)	

2.6 Training

No	Sub-factors	Ranking
2.6.1	Induction course for all personnel	
2.6.2	Team training	
2.6.3	Technical competence training & assessment	
2.6.4	Emergency response training	
2.6.5	On-going training for specific tasks	
2.6.6	Toolbox talks	
2.6.7	Others (please state)	

2.7 Communication

No	Sub-factors	Ranking
2.7.1	Procedure for reporting incidents/accidents	
2.7.2	Procedure for reporting near misses	
2.7.3	Procedure for conveying instruction	
2.7.4	Procedure/channel for recommendations & improvements	
2.7.5	Suggestion scheme	
2.7.6	Poster campaigns, safety booklets	
2.7.7	Proper signage	
2.7.8	Health & Safety committee (management & employees)	
2.7.9	Others (please state)	

2.8 Safety culture

No	Sub-factors	Ranking
2.8.1	Everybody knows the safety rules & standards	
2.8.2	Workers exhibit safe behaviour	
2.8.3	Safe behaviour related to tool/equipment, machinery	
2.8.4	Employees use PPE when appropriate	
2.8.5	Safe working environment exists	
2.8.6	Employees know where the safety equipment is & how to use it	
2.8.7	Employees make time to be safe	
2.8.8	Operatives involved in safety audit	
2.8.9	Others	

2.9 Health

No	Sub-factors	Ranking
2.9.1	Physical stress check-up	
2.9.2	Emotional stress check-up	
2.9.3	Pre-employment medical	
2.9.4	Regular health surveillance	
2.9.5	Health risk assessment	
2.9.6	Medical facilities (including first-aid facilities)	
2.9.7	Others (please state)	

APPENDIX 5.2 – SURVEY II QUESTIONNAIRES

Dear Panellist,

The aim of this exercises is to explore and assess the numerous indicators involved for the outcome evaluation of safety performance at construction site.

The survey sets out to provide an organised method for correlating views and information pertaining to safety issues that affect safety performance.

In this questionnaires, the following are observed:-

1. REVIEW all the indicators on the questionnaires.
2. MAKE COMMENT on any issue you wish. Feel free to suggest clarification, argue in favour of or against issues, ask questions.
3. RATE the level of IMPORTANCE of each indicators as follows:-

(1)	Very Important	A most relevant point First order priority Has direct bearing on major issues
(2)	Important	Is relevant to the issue Second order priority Significant impact but not until other items are treated Does not have to be fully resolved
(3)	Moderately important	May be relevant to the issue Third order priority May have impact May be a determining factor to major issue
(4)	Unimportant	Insignificantly relevant Low priority Has little impact Not a determining factor to major issue
(5)	Most unimportant	No priority No relevance No measurable effect Should be dropped as an item

4. RETURN your response by ....(date).

F1 TECHNIQUES USED BY HEAD OFFICE MANAGEMENT (HOM)
SF1.1 CARRY OUT SAFETY AUDIT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
1.1.1	HOM conduct safety audit on annual basis						
1.1.2	HOM participate in safety audit						
1.1.3	HOM personnel involved in safety audit received pre-audit training						
1.1.4	using statistical technique & actual count to ensure validity of safety audit						
1.1.5	developing an action plan to meet programmes needs as indicated by safety audit						
1.1.6	periodic review of audit action plan to determine progress						
1.1.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F1 TECHNIQUES USED BY HEAD BASED MANAGEMENT (HOM)
SF1.2 UP-TO-DATE SAFETY DOCUMENTS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
1.2.1	safety documents exist						
1.2.2	where needs & changes in requirements occur, revision is made						
1.2.3	site-based management are advised on the changes						
1.2.4	up-dated version will replace all existing documents						
1.2.5	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F1 TECHNIQUES USED BY HEAD OFFICE MANAGEMENT (HOM)
SF1.3 HAZARD ANALYSIS DURING DESIGN & PLANNING STAGE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
1.3.1	HOM must understand the provision of information about aspects of the design that might affect h&s plan of people on site or affected by the work						
1.3.2	compliance with the legislation - the existence of a pre-tender h&s plan at the same time as the tender documents						
1.3.3	compliance with the legislation - the inclusion of the h&s file						
1.3.4	workplace design & layout examined for h&s factors						
1.3.5	a system for reviewing new facilities prior to start-up to identify residual risk not eliminated through engineering procedures						
1.3.6	others						

1 = very important, 2 = important, 3 - moderately important 4 = unimportant, 5 = most unimportant

F1 TECHNIQUES USED BY HEAD OFFICE MANAGEMENT (HOM)
SF1.4 PROCEDURES FOR REPORTING ACCIDENT/INCIDENTS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
1.4.1.	company have reporting system for accident/incident which is compatible with legislative requirements for • fatality • major accident/incident • lost days • doctor's cases						
1.4.2	ensure all site personnel know the reporting procedures set by the company						
1.4.3	company provide competent and well trained staff with clearly defined responsibilities for accident/incident reporting						
1.4.4	confirm all reporting in writing						
1.4.5	conduct an analysis of all accident/incident						
1.4.6	conduct meeting not later than the next working day after a major accident/incident & fatality						
1.4.7	consideration & decision of the accident incident review meetings recorded & distributed to supervisors & sub-contractors						

1 very important, 2 - important, 3 - moderately important, 4 - unimportant, 5 - most unimportant

F1 TECHNIQUES USED BY HEAD OFFICE MANAGEMENT (HOM)
SF1.5 PROCEDURES FOR REPORTING NEAR MISSES

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
1.5.1	company has reporting system for reporting near misses						
1.5.2	all site personnel know the reporting procedures set by the company						
1.5.3	company provide competent and well trained staff with clearly defined responsibilities for near misses reporting						
1.5.4	confirm all reporting in writing						
1.5.5	near-misses reported during management meeting recorded on forms or in meeting minutes						
1.5.6	written follow-up procedures by appropriate personnel to deal with near misses						
1.5 7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT (SM)
SF2.1 UP-TO-DATE SAFETY DOCUMENTS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.1.1	safety documents *example manuals,* procedures & standards exist						
2.1.2	personnel can refer to the safety documents at any time						
2.1.3	when future needs & changes in requirements occur, revision will be made						
2.1.4	personnel will be advised on the changes						
2.1.5	ensure the safety documents are kept in good condition						
2.1.6	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT (SM)
SF2.2 SAFETY POLICY

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.2.1	clear statements of company policy, objectives & expectation of all site personnel with regard to safety						
2.2.2	restrict the policy statement to one A4 or A3, be concise & action-oriented statements						
2.2.3	safety policy statement endorsed & dated by senior executives of the company						
2.2.4	company safety policy displayed in a conspicuous place						
2.2.5	sub-contractor safety policy is displayed in a conspicuous place						
2.2.6	safety policy is regularly reviewed with emphasis on its intent, scope & adequacy						
2.2.7	a summary of disciplinary action of violating any company rules & procedures						
2.2.8	others						

1 very important, 2 = important 3 moderately important, 4 unimport nt 5 most un mp rtant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT (SM)
SF2.3 FULL TIME SAFETY OFFICER

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.3.1	safety officer be on site at least 75% of his time each working day						
2.3.2	safety officer must be fully trained						
2.3.3	safety officer responsible for activities which help the company to achieve its goal in safety						
2.3.4	safety officer to analyse needs, co-ordinate the formulation of remedies & help company to implement the practical work programme						
2.3.5	safety officer ensure that safety is included in all the training programmes						
2.3.6	safety officer identify & carry out appraisal of accident/incident condition & practices, evaluation of the severity of the accident problems						
2.3.7	safety offi er develop accident/incident & near misses prevention method						
2.3.8	measurement & evaluation of the effectiveness of the safety programme & the mod fication eeded to achieve optimum results						

1– r importan t 2 – import nt 3 moder tel mport nt 4 – un n p rtant 5 – m st in t portant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT (SM)
SF2.4 MOTIVATING PERSONNEL ON SITE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.4.1	SM establish attainable goals & give encouragement to motivate site personnel over a long period of time						
2.4.2	SM practice the concept of job-enrichment as in • active participating of site personnel in decision making • personnel ideas, perception of problems & solutions are sought & cultivated						
2.4.3	SM make personnel realise the direct cost of accident/incident						
2.4.4	set up targets and charts including safety to plot progress; updated regularly to keep personnel interested						
2.4.5	SM provide conducive physical working environment						
2.4.6	recognition of good safety performance; offer good fringe benefits, public recognition, authority & promotion by SM						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.4.7	SM encourage safe working by making it the easy option & rewarding safe performance						
2.4.8	SM ensure that safety posters are renewed frequently, so that they do not become old and 'part of the furniture' *to give maximum* motivation						
2.4.9	good communication is essential for safety motivation - assign responsibility & make safety officer accountable						
2.4.10	others						

1= very important, 2 = important, 3 = moderately important, 4- unimportant, 5 - most unimportant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT (SM)
SF2.5 MEETINGS WITH SUPERVISORS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.5.1	planned meeting held at least once a week						
2.5.2	informal meeting held at least 6x/month						
2.5.3	meetings held to discuss current issues relating to h&s						
2.5.4	attendance recorded						
2.5.5	review any near miss incidents						
2.5.6	recommendation and suggestions discussed at this meeting						
2.5.7	followed-up by appropriate personnel on significant items reported during meeting						

1= very important, 2 = important, 3 – moderately important, 4= unimportant, 5 = most unimportant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT (SM)
SF2.6 MEETINGS WITH SUB-CONTRACTOR & SUPPLIERS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.6.1	planned meeting at least 3x/month						
2.6.2	attendance recorded						
2.6.3	review of observed actual or possible safety violation						
2.6.4	review of safety performance throughout the project						
2.6.5	written report of meeting being circulated to all sub-contractor & suppliers						
2.6.6	feedback on action carried out by affected sub-contractor & suppliers						
2.6.7	all information from the meeting to be communicated to the workforce via tool-box talks						
2.6 8	others						

1– very important, 2 – important, 3 – moderately important, 4– unimportant, 5 – most unimportant

F2 TECHNIQUES USED BY SITE-BASED MANAGEMENT
SF2.7 SELECTION OF SUB-CONTRACTOR

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
2.7.1	prospective sub-contractors & suppliers are required to submit a h&s requirement contained in the initial tender document as well as contract						
2.7.2	pre-qualification questionnaires designed to assess a contractors safety policy, past experience & safety performance						
2.7.3	pre-qualification visit to companies of prospective suppliers						
2.7.4	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F3 TECHNIQUES USED BY SITE SUPERVISORS
SF3.1 INSPECTION

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
3.1.1	carry out planned inspection daily						
3.1.2	carry out informal inspection 4x/month						
3.1.3	inspection carried out by trained personnel						
3.1.4	plan what to inspect • review applicable regulations • know the hazard involved • choose a specific inspection route • use inspection checklist						
3.1.5	take action on all substandard conditions & practices during inspection classified as hazard potential						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 ~ most unimportant

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
3.1.6	written report on all substandard conditions & practices						
3.1.7	written procedures to ensure all items are corrected in order of priority						
3.1.8	a copy of each planned inspection report given to the appropriate sub-contractor for remedial action						
3.1.9	all acceptable follow-up systems should define • specific responsibilities • time scale • person to whom report should be forwarded • records to be stored • methods of verification						
3.1.10	periodic analysis of complete observation report made to identify repetitive substandard acts & their basic underlying causes						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F3 TECHNIQUES USED BY SITE SUPERVISORS
SF3.2 REGULAR TOOL-BOX TALK

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
3.2.1	carried out by trained personnel						
3.2.2	focused on gang's particular work						
3.2.3	keep the talk short - approximately 10 minute						
3.2.4	carry out the talk on weekly basis						
3.2.5	develop checklist or reminder sheet for tool-box talk						
3.2.6	company should have a record of all the tool-box talk carried out						
3.2.7	others						

1= very important, 2 = important, 3 = moderately important, 4– unimportant, 5 – most unimportant

F3 TECHNIQUES USED BY SITE SUPERVISORS
SF3.3 INCIDENT AND NEAR MISSES REVIEW & REPORTING

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
3.3.1	conduct periodic discussion with supervisor about all incidents and near misses observed during that time						
3.3.2	review the frequency of occurrence of each incident and near miss						
3.3.3	involve site personnel together with management in the process to find a solution for incidents and near misses						
3.3.4	file record of all discussion for future reference						
3.3.5	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F3 TECHNIQUES USED BY SITE SUPERVISORS
SF3.4 PRE-TASK AWARENESS TALK

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
3.4.1							
3.4.2							
3.4.3							
3.4.4							
3.4.5							
3.4.6							

TF input requested for indicators for those sub-factors

1 very important, 2 = important, 3 = moderately important, 4 = unimportant, 5 = most unimportant

F4 ENGINEERING CONTROL
SF4.1 RISK ANALYSIS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
4.1.1	carry out risk analysis for selected jobs • look out for hazards • who might be harmed • develop ways to eliminate the hazards • evaluate the remaining risks • compliance with legislation						
4.1.2	record all findings						
4.1.3	upon completion, review the analysis with worker involved who may have valuable addition						
4.1.4	provide a copy of the analysis to the worker						
4.1 5	use this analysis in future orientation & training sessions						
4 1.6	rev ew the assessment and revise if necessary						
4.1 7	others						

1 – very important 2 = important 3 moderately important. 4 unimportant 5 most un mportant

F4 ENGINEERING CONTROL
SF4.2 METHOD STATEMENT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
4.2 1	produce method statement for each job that has inherent difficulties or significant risks in its execution, either by those carrying out the work or those near the work location						
4.2.2	identification of individual(s) who are responsible for ensuring compliance with the method statement						
4.2.3	the date and origin of all method statements should be clearly shown						
4.2.4	the method statement should be in sufficient detail to provide the correct sequence of work description of all high risk activities						
4.2.5	communicate detail of method statement to appropriate personnel						
4 2.6	ensure that contingencies are planned for and clear lines of responsibilities established						
4 2 7	others						

1 very in portant 2 – important 3 – moderatel important 4 unimportant 5 – most unimp rtant

F4 ENGINEERING CONTROL
SF4.3 WORK PROCEDURES

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
4.3.1	all procedures are written in a practical, easy to follow and fully understood by workforce						
4.3.2	all written procedures should be indexed for easy reference						
4.3.3	ensure all equipment that is required in the procedures is properly maintained						
4.3.4	place a system of feedback to update procedures and make necessary changes						
4.3.5	others						

1 very important, 2 important, 3 – moderately important 4 – unimportant 5 – most unimportant

F4 ENGINEERING CONTROL
SF4.4 PERMIT TO WORK

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
4.4.1	set up a permit to work system for any job where there is risk, e.g. non-routine work where more than one worker is interacting on a job						
4.4.2	recognise which type of permit is required						
4.4.3	establish if more than one permit is needed, or if the whole aspect is covered by the permit used						
4.4.4	the permit to work document should incorporate check lists of all the preparatory steps, and when completed, should contain a list of all the equipment needed to carry out the job						
4.4.5	ensure the permit identifies hazards and establishes precautions that need to be taken						
4.4.6	permits should be issued and accepted by technically competent persons who are familiar with the system and equipment						
4.4.7	the permit must be properly authorised and accepted before work commences						
4.4.8	as far as reasonably practicable, only the issuer can cancel, alter or override the permit						
4.4.9	others						

1 – very important 2 important 3 moderately important 4 unimportant 5 – most unimportant

F4 ENGINEERING CONTROL
SF4.5 MACHINERY AND EQUIPMENT IN GOOD WORKING CONDITION

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
4.5.1	machinery and equipment manuals exist on site						
4.5.2	availability of the complete manuals for review & reference						
4.5.3	employee booklet - general guidelines & instructions for all equipment & machinery						
4.5.4							

1= very important. 2 = important. 3 = moderately important. 4= unimportant. 5 = most unimportant

F4 ENGINEERING CONTROL
SF4.6 RIGHT PERSON FOR THE RIGHT JOB (applicable to all personnel on site)

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
4.6.1	applicant must have the right skills and knowledge to carry out the job/task						
4.6.2	reference from previous employer who is in a position to assess the applicant's past performance & personality						
4.6.3	objective data from the applicant's history such as family background, school record, experience at related job, career pattern, geographical origin & so on						
4.6.4	an interview that reveals some of the applicants characteristic communication skills						
4.6.5	a probationary period during which the applicant is observed in the actual work situation or a training situation						
4.6.6	psychological test of general ability, intelligence, special aptitudes & manipulative skills						
4.6.7	others						

1= very important. 2 = important. 3 = moderately important. 4= unimportant. 5 = most unimportant

F5 HOUSEKEEPING
S5.1 GOOD STORAGE PRACTICE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
5.1.1	storage area should avoid crossflow of traffic & minimise movement, main gangway should be central & run lengthways to shorten the more difficult access ways						
5.1.2	items of stock should be grouped generally into those frequently in demand & those less frequently in demand, placing the former nearer to the point of issue						
5.1.3	in open areas where space allows, the flow of traffic should be one-way to avoid delays						
5.1.4	any particular valuable, perishable or hazardous material should receive special attention and be located where they can be more secure and frequently supervised by the storekeeper						

1- very important, 2 = important, 3 - moderately important, 4= unimportant, 5 = most unimportant

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
5.1.5	the use of 'open-mesh' fencing for division, compartments or perimeters fence assist security, increase visibility, helps to avoid accidents and encourage a tidy site						
5.1.6	the location of material should be planned by reference to the construction programme, allowing alternative use of space as soon as possible but making sure another delivery of the previous materials is not imminent						
5.1.6	utilisation of available height in storage should be given to proper stacking, and the use of shelves, racks, pallets appropriate to the material.						
5.1.7	where storage area is not covered, resurfacing with additional hard-core or concrete should be a priority task where deep ruts or potholes developed.						
5.1.8	use of equipment as below will allow more effective use of available space:- • bins for small items • racks • pallets • tubular steels stand						
5.1.9	others						

1 very important, 2 = important, 3 = moderately important, 4= unimportant, 5 most unimportant

F5 HOUSEKEEPING
S5.2 HAZARD IDENTIFICATION

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
5.2.1	hazard communication manual to personnel dealing directly with it - manual contains • properties of material • procedures for handling the various chemicals & material required in performance of their responsibilities • measure of personal protection that can be taken against these chemicals						
5.2.2	all containers are properly labelled						
5.2.3	appropriate initial training in handling and safe use of hazardous chemical at work						
5.2.4	emergency procedures, alarms & clean-up materials in place to handle chemicals releases and other occupational health emergencies						
5.2.5	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F5 HOUSEKEEPING
S5.3 PROPER WASTE MANAGEMENT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
5.3.1	to avoid delivery waste, give correct specification and latest amendments to suppliers						
5.3.2	ensure all packed delivered materials are properly packed						
5.3.3	where delivery is self-loaded, avoid careless handling into storage						
5.3.4	proper storage of goods						
5.3.5	always carry out work to accurate dimensions e.g. excavations						
5.3.6	always use the correct conversion ratios for compaction of bulk item e.g. order by tonne and paying by m3						
5.3.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F6 TRAINING
SF6.1 INDUCTION COURSE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
6.1.1	Induction for all personnel who set foot on site						
6.1.2 a	Content of induction to cover the following:- safety rules and regulation responsibilities for all personnel						
b	Personnel rights & responsibilities under the legislation						
c	explain site management hierarchy & introduce personnel to his/her supervisor						
d	notify personnel of emergency plan						
e	location of medical & emergency aid; who is the first aider(s) on site						
f	inform about risks of the work & precautions to be taken						
g	explain site layout & if possible conduct tour of work place, noting danger, exits, etc.						
h	explain the arrangement & need for good housekeeping						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
i	explain permit-to-work system & method statement(s)						
j	Issue of PPE needed, make sure it fits properly, make aware how & when to wear it, how to look after it & report defects						
k	explain security system, issue of passes & permits						
l	overview of company procedures & use of various forms						
6.1.3	Use written material & visual aids to conduct induction course						
6.1.4	carry out evaluation at the end of the course either in the form of Q & A or pen and paper.						
6.1.5	identification system for all those who had attended the induction course						
6.1.6	follow-up session a week after the induction to make sure questions can be answered & comments made						
6.1.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F6 TRAINING
SF6.2 TEAM TRAINING

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
6.2.1	program exists to facilitate workers to learn the functions of role of the entire operation with which the team will work						
6.2.2	facilitate the change from the individual to team work - workers must know how the job fits together to contribute to the end product						
6.2.3	introduce elementary team psychology to help members to understand their own reactions & defence mechanism to resolve interpersonal problems within the group						
6.2.4	establish a realistic, agreed upon production goal for the team						
6.2.5	evaluation of the performance to ensure the team is competent to handle the work situation						
6.2.6	give immediate feedback to team on their performance						
6.2.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F6 TRAINING
SF6.3 TECHNICAL COMPETENCE TRAINING & ASSESSMENT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
6.3.1	formal training programme have lesson plan developed to guide and standardised content & quality						
6.3.2	carry out training for both theory and practical (on job) training						
6.3.3	test for competence either by written test or demonstration						
6.3.4	all competence results recorded and filed appropriately for reference						
6.3.5	operators requiring licence for mobile equipment & other position have specialised competence training						
6.3.6	the award of certificate is based on competency level rather than test of skills						
6.3.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F6 TRAINING
SF6.4 EMERGENCY RESPONSE SYSTEM

Ind Nos	Indicators	Comments	Rank				
			1	2	3	4	5
6.4.1	inform all personnel of necessary action to be taken during an emergency						
6.4.2	location of medical & emergency aid; make known who is the first aider(s)						
6.4.3	place all emergency phone numbers in conspicuous places throughout the job site						
6.4.4	carry out drills which simulate the real occurrence of • fire • accident fatal • property damage • public demo • bomb threat						
6.4.5	emergency response plan is required for all potential emergencies involving hazardous substances						
6.4.6	training is required for all workers who respond to any emergencies involving hazardous substances						
6.4.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F6 TRAINING
SF6.5 ON SITE SAFETY TRAINING

Ind Nos	Indicators	Comments	Rank				
			1	2	3	4	5
6.5.1	address problem which may be peculiar to specific tasks						
6.5.2	alert workforce to problems which may not have been anticipated at earlier planning stages						
6.5.3	reaffirm company & site policy on safety procedures						
6.5.4	utilise feedback from safety inspection or accident investigations to highlight new or recurring problems						
6.5.5	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F6 TRAINING
SF6.6 TOOL-BOX TALK

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
6.6.1	conducted by foremen, supervisors and sub-contractors						
6.6.2	talk focused on the gang's particular work						
6.6.3	keep the talk short						
6.6.4	conduct the talk on weekly basis						
6.6.5	develop a checklist or reminder sheet for tool-box talk						
6.6.6	training to help improve the foreman's skills in conducting tool-box meetings						
6.6.7	company should keep a file on all the tool-box talk conducted by sub-contractor						
6.6.8	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F7 COMMUNICATION
SF7.1 PROCEDURES FOR RECOMMENDATION, SUGGESTION OR IMPROVEMENTS

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
7.1.1	informal system where personnel are encouraged verbally to make safety suggestion, recommendations or improvements						
7.1.2	formal systems which involve active promotion of written safety suggestions with some form of official review of the proposals						
7.1.3	the improvement, suggestion or proposal system must be an on-going procedure						
7.1.4	many forms of implementing the system, either through suggestion box , phone or signed safety suggestion forms						
7.1.5	reward personnel who had given any proposal, suggestion or improvements - reward can vary, minimum verbal recognition						
7.1.6	make known to all personnel once a suggestion has been accepted and who suggested it.						
7.1.7	commendation can be given spontaneously or in planned ceremonies						
7.1.8	all commendation must be followed by a written communication from management						
7.1.9	visible results e.g. sticker worn on hard hats						

1 = very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F7 COMMUNICATION
SF7.2 PROCEDURES FOR CONVEYING INSTRUCTION

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
7.2.1	chain of command - management will communicate with supervisors under their direction who in turn send the information on to their subordinates						
7.2.2	direct contact system - managers communicate directly with workers & foreman, walk frequently and feel free to contact and talk directly with any individuals on the job						
7.2.3	group meeting - job-site managers relies on meetings with different supervisory groups and with groups of crafts workers						
7.2.4	communication can be regularly scheduled, may be called for special purposes or on an informal basis						
7.2.5	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F7 COMMUNICATION
SF7.3 SAFETY POSTER

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
7.3.1	put up adequate notice boards for health & safety purposes						
7.3.2	language use must be understood by all personnel						
7.3.3	location of safety notice board must be seen by workers at least once during the working day						
7.3.4	place safety poster right at the entrance to emphasise the company's strong commitment to safety						
7.3.5	change safety poster at least every fortnight						
7.3.6	hand out related safety booklet and safety handbook to employees on the first day of work after the induction course						
7.3.7	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F7 COMMUNICATION
SF7.4 SAFETY SIGNAGE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
7.4.1	put up adequate signage for health & safety purposes						
7.4.2	identify signs & colour codes which should be in place at the site and evaluate the adequacy of existing signs & colour codes						
7.4.3	determine the degree of compliance with statutory requirements for instructional signs & colour codes						
7.4.4	introduce colour codes in the safety handbook when handed out after the induction course						
7.4.5	damaged signs or notices should be repaired and quickly replaced						
7.4.6	others						

1= very important. 2 = important. 3 = moderately important. 4= unimportant. 5 = most unimportant

F7 COMMUNICATION
SF7.5 HEALTH & SAFETY COMMITTEE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
7.5.1	safety committee to include various levels of management, safety practitioners & employees						
7.5.2	safety committee to improve the evaluation process of reviewing problems and developing alternative solutions to them						
7.5.3	safety committee to add co-ordination to a safety programme, develop safety satisfaction & motivation tool						
7.5.4	others						

1= very important. 2 = important. 3 = moderately important. 4= unimportant. 5 = most unimportant

F8 SAFETY CULTURE
S8.1 EVERYBODY EXHIBIT SAFE BEHAVIOUR

Ind Nos	Indicators	Comments	Rank				
			1	2	3	4	5
8.1.1	everybody aware of all company rules and policies						
8.1.2	personnel comply with company rules & policies						
8.1.3	comply with direction given to them by their supervisors						
8.1.4	store & maintain all equipment, tools etc., in ways that are orderly clean and will ensure their continuing safe operation & use						
8.1.5	immediately report all accidents and injuries to their supervisors, no matter how slight in appearance						
8.1.6	workers wear PPE when appropriate and required, without force from supervisor						
8.1.7	report working conditions that are apparently unsafe or suspected of being unsafe to their supervisors						
8.1.8	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F8 SAFETY CULTURE
S8.2 SAFE BEHAVIOUR RELATED TO TOOL, EQUIPMENT OR MACHINERY

Ind Nos	Indicators	Comments	Rank				
			1	2	3	4	5
8.2.1	company vehicles must be checked by their drivers each morning before leaving the yard - all safety items must be confirmed to be operatives						
8.2.2	only company trained or experienced operators are authorised to tow trailers						
8.2.3	the drivers must verify that any towed equipment should have two safety chains and adequate strength to maintain the towed objects						
8.2.3	the driver is responsible to verify that vehicles are properly loaded at all times and that loads are thoroughly and properly secured						
8.2.4	the drivers is responsible that all flatbed trucks (dump, high-lifts etc.) have tailgate or toeboards						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
8.2.5	equipment operator report any unsafe conditions of either the equipment or the job-site to the foreman						
8.2.6	machinery and merchandised equipment operated only by specifically designated personnel						
8.2.7	equipment without a designated operator such as pumps, falls under the responsibility of the foreman for maintenance						
8.2.8	riding on equipment or loads is strictly prohibited, unless the equipment has been specifically designed for that purpose						
8.2.9	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F8 SAFETY CULTURE
S83 PERSONNEL USE PPE WHEN APPROPRIATE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
8.3.1	personnel always wear PPE when appropriate & required without force from supervisor						
8.3.2	personnel must always keep the PPE clean and in good repair						
8.3.3	personnel wears PPE that suits the wearer in terms of size & height, they are also trained on how to use it						
8.3.4	personnel will ensure that safety shields & guards are in place and secured on all equipment prior to commencement of equipment operations						
8.3.5	only approved shoring devices shall be used in all trenching operations as required by the legislation						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
8.3.6	all personnel shall wear protective hard hat at all times in all construction area including any building, trenches & open sites - the only exception are job-site field office & any finished building areas						
8.3.7	use all required PPE such as hard hats, vests & safety goggles whenever appropriate & required						
8.3.8	safety goggles must be worn when using power tools, sledge hammers, cutting tools or while performing any task where there may be a danger of flying particles which might cause eye injury						
8.3.9	appropriate work shoes or boots must be worn on the job, preferably steel-toes & made of leather. Sneakers, tennis shoes, sandals & similar footwear are not acceptable						
8.3.10	employee to return used or damaged PPE to receive a re-issue						
8.3.11	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F8 SAFETY CULTURE
S8.4 SAFE WORKING ENVIRONMENT EXIST

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
8.4.1	proper support & guards						
8.4.2	proper illumination						
8.4.3	proper ventilation						
8.4.4	work place is not congested						
8.4.5	all tool & equipment are effective						
8.4.6	orderly workplace						
8.4.7	proper warning & detection system						
8.4.8	others						

1– very important, 2 = important, 3 – moderately important, 4– unimportant, 5 = most unimportant

F8 SAFETY CULTURE
S8.5 EVERYBODY KNOWS WHERE SAFETY EQUIPMENT IS & HOW TO USE IT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
8.5.1	all personnel have undergone emergency training either during • induction course • team training • emergency response system • on going training for specific task • tool-box talk						
8.5.2	practical & theoretical training are conducted on how to use the safety equipment						
8.5.3	further information on unsafe & identification of safety equipment is available in the handbook given to all employees after the induction course						
8.5.4	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F8 SAFETY CULTURE
S8.6 EVERYBODY MAKE TIME TO BE SAFE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
8.6.1	employer communicate the priority of safety to the entire workforce to their first task on a new project						
8.6.2	when personnel know that safety comes first, they will make their decision so that each job is done in the safest manner						
8.6.3	statement about priorities is embedded in every action which the employees take in every stage of a project's life						
8.6.4	always keeping safety in the forefront of each person's mind is a continuing, never - ending job throughout the project						
8.6.5	employee will stop work if he/she considers that it would be unsafe to continue - work safely or not at all						
8.6.6	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F9 HEALTH
S9.4 MEDICAL FACILITIES

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
9.4.1	report all job related injuries, no matter how minor to the immediate supervisor						
9.4.2	first aid & medical facilities appropriate for the size and type of project						
9.4.3	inform all personnel where the first-aid and medical facilities are during induction course						
9.4.4	company should have appropriate number of qualified first-aid personnel						
9.4.5	additional training for life saving skills for other personnel						
9.4.6	medical personnel available for advice and consultation on matter of occupational health						
9.4.7	demonstration of regular checks/audit of first-aid/medical facilities						
9.4.8	emergency telephone numbers or mobile communication must be conspicuously posted on site						
9.4.8	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F9 HEALTH
S9.3 HEALTH RISK ASSESSMENT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
9.3.1	adequate prevention measures exist to control and identify potential health risk						
9.3.2	control applied to the acquiring, handling, storing, dispensing and disposal of each known hazardous material						
9.3.3	current inventory of all chemical substances to identify their chemical names and related hazardous exposure						
9.3.4	all workers exposed to potential health risk is given proper written job -instruction with emphasis on occupational health topics						
9.3.5	in area of health hazard, regular monitoring exists to measure the exposures and verify that the hazards are being controlled at safe level						
9.3.6	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F9 HEALTH
S9.1 PRE-EMPLOYMENT HEALTH ASSESSMENT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
9.1.1	all employees received a pre-employment physical examination				✓		
9.1.2	the pre-employment physical examination include tests to detect pre-existing conditions				✓		
9.1.3	this pre-employment assessment is to determine worker's fitness for the post/task that is being conducted				✓		
9.1.4	this assessment will be carried out for each new post involving in a change in the type of risk				✓		
9.1.5	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F9 HEALTH
S9.2 REGULAR HEALTH SURVEILLANCE

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
9.2.1	regular medical examination carried out on employees exposed to identify health hazard to verify that the preventive controls are providing adequate protection	IN SPECIFIED OCCUPATIONS	✓				
9.2.2	formal procedures exist to review industrial hygiene monitoring results and to monitor follow-up actions until they are fully implemented	— " —	✓				
9.2.3	all monitoring of identified chemical, biological & physical agents is properly maintained in accordance with industry or consensus standards & statutory requirements		✓				
9.2.4	health care programme in the company which include periodic exam or test, as indicated by health hazard exposures or required by legislation		✓				
9.2.5	employees health record maintained and stored in permanent confidential files		✓				
9.2.6	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F9 HEALTH
S9.3 HEALTH RISK ASSESSMENT

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
9.3.1	adequate prevention measures exist to control and identify potential health risk						
9.3.2	control applied to the acquiring, handling, storing, dispensing and disposal of each known hazardous material						
9.3.3	current inventory of all chemical substances to identify their chemical names and related hazardous exposure						
9.3.4	all workers exposed to potential health risk is given proper written job -instruction with emphasis on occupational health topics						
9.3.5	in area of health hazard, regular monitoring exists to measure the exposures and verify that the hazards are being controlled at safe level						
9.3.6	others						

1= very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

F9 HEALTH
S9.4 MEDICAL FACILITIES

Ind Nos	Indicators	Comments	Rank 1	2	3	4	5
9.4.1	report all job related injuries, no matter how minor to the immediate supervisor						
9.4.2	first aid & medical facilities appropriate for the size and type of project						
9.4.3	inform all personnel where the first-aid and medical facilities are during induction course						
9.4.4	company should have appropriate number of qualified first-aid personnel						
9.4.5	additional training for life saving skills for other personnel						
9.4.6	medical personnel available for advice and consultation on matter of occupational health						
9.4.7	demonstration of regular checks/audit of first-aid/medical facilities						
9.4.8	emergency telephone numbers or mobile communication must be conspicuously posted on site						
9.4.8	others						

1 = very important, 2 = important, 3 = moderately important, 4= unimportant, 5 = most unimportant

01

APPENDIX 5.3– SURVEY III QUESTIONNAIRES

METHODOLOGY TO DEVELOP A PROACTIVE SAFETY PERFORMANCE MEASUREMENT TECHNIQUE (SPMT) FOR CONSTRUCTION

An industrial survey of current practices

Drucker's (1994) maxim 'what's get measured, gets done' is a reminder of the importance of measuring performance. Thus the aim of this study is to develop a single measurement tool to measure safety performance on construction sites. The two ways of generating information on performance for construction are the traditional approach that is reactive and considers historical data and the more dynamic approach that proactive and considers culture, training and behaviour. The study will concentrate on developing proactive performance measures for construction. SPMT will be a measurement tool that will be able to identify substandard performance, allow a more focused remedial action and evaluate the progress or retrogress of safety performance on sites.

This is the third stage of the study. The first two stages have enabled us to identify the important factors and sub-factors. This stage is to validate the identified sub-factors and the indicators for developing SPMT. The questionnaire is divided into four sections that are:
1.0 – General information
2.0 – Company safety performance self-assessment
3.0 – Ranking the sub-factors
4.0 – Ranking the indicators

We would be grateful if you could spare a few minutes to fill the questionnaire and post to us in the self addressed envelope enclosed before ....

ECI
Sir Arnold Hall Building
Loughborough University
Loughborough LE11 3TU

Attn:	Mr Alistair Gibb	Miss R.K. Ahmad
Tel	01509 223097	01509 263171 ext 4288
Fax	01509 223981	
Email	A.G.Gibb@lboro.ac.uk	R.K-Ahmad@lboro.ac.uk

Would you like to receive a summary of the results? **Yes** **No**

Would you be willing to be involved in future development of SPMT **Yes** **No**

Your assistance in completing the questionnaire is very much appreciated. Thank you.

1.0 GENERAL INFORMATION

1.1 Company name

....

1.2 Company address

....
....
....

1.3 Job title (please state)

....

1.4 Contact name

....

Contact phone..

Contact fax ....

Contact email ....

1.5 Please indicate below the main sector of work for the company (or part of the company) that you represent
(Please tick the appropriate box)

Private Commercial	☐
Industrial	☐
Infrastructure	☐
Civil Engineering	☐
Public Sector	☐
Public Sector Housing	☐
Engineering Construction	☐
Others *(please state)*	☐

5c

2.0 COMPANY SAFETY PERFORMANCE SELF-ASSESSMENT

This section is to investigate the company's self-assessment of the safety performance of its site

2.1 Do you carry out site safety performance assessment? Yes No

2.2 If yes, please answer the following:
Ai Which approach is adopted? *(Please tick the appropriate box)*

Reactive approach (post-accident e.g. RIDDOR, LTA)
Proactive approach (pre-accident e.g. training, safety culture)
Both the proactive and reactive approach

Aii Please indicate which statement best describe your current safety measurement system *(please tick the appropriate box)*

Have developed own in-house system
Customise a standard system
Use a system developed externally *(please state)*
....

Aiii How has your approach changed in the last 5 years?
....
....
....
....
....
....

B For each site:
i How long does the assessment last? *(e.g. 1 day, 2 days)*..

ii. How frequent is the assessment? *(e.g. every month)*..

iii. How much human resource is committed to carry out each safety performance assessment? *(e.g. man hours, days)*

External examiner .... Managerial level (HQ) ....
Site management .... Site supervisors ....
Operatives .... Others........................ ....

iv Which of the following methods are used? *(You may tick more than one answer)*

Questionnaires
Interviews
Document checks

Checklists
Observations
Others ....

v Are the results made known to everyone on site? Yes No

vi Regarding actions following an assessment, please tick the statement that most closely represents your practice

No actions taken
Actions resulting from assessment are rare & usually minor
Actions are agreed, recorded & reviewed
Actions are taken at the time but no record is kept

3.0 RANKING OF SUB-FACTORS

The sub-factors that we intend to measure are grouped under three headings namely, hardware (engineering system and control for plant and equipment), software (management, work system and procedures) and people. From the lists below, please rank the sub-factors in order of importance for inclusion in an effective safety system. This will enable us to develop a scoring system for each sub-factor.

Where 1 is the most important and 12 is the least important

Sub-factors **(Hardware)**	Order of importance
Pre-tender risk assessment	
Site inspection	
Tool-box talks	
Construction risk analysis	
Method statements	
Permit-to-work system	
Machinery & equipment in safe working condition	
Good housekeeping	
Material Safety Health Data Sheet	
Induction training	
Emergency response system	
Safety poster, signs and notice boards	

Where 1 is the most important and 13 is the least important

Sub-factors **(Software)**	Order of importance
Safety audit	
Up-to-date safety documentation	
Procedures for reporting accidents/incidents	
Procedures for reporting near misses	
Up-to-date safety policy	
Safety meeting with supervisors	
Safety meeting with sub-contractors	
Procedures for recommendation, suggestion or improvement	
Procedures for conveying instructions	
Safe working environment	
Effective health care	
Safety officer	
Health & Safety Committee	

Where 1 is the most important and 4 is the least important

Sub-factors **(People system)**	Order of importance
Motivation to safe behaviour	
Selection of sub-contractors based on safety issues	
Right person for the right job	
Safe behaviour	

4.0 RATIING THE INDICATORS

The sub-factors in 3.0 are measured by evaluating indicators. In your opinion, which of the following indicators are more important. *(Please circle the most appropriate answer)*

Where 1=absolutely essential; 2=very important; 3=important; 4=of little importance; 5=not important; 6=don't know

No	Sub-factors	Indicators	absolutely essential	very important	important	of little importance	not important	don't know
1	Carry out safety audit	Participation in safety audit	1	2	3	4	5	6
		Pre-audit training	1	2	3	4	5	6
		Frequency of safety audit	1	2	3	4	5	6
		Safety audit analysis	1	2	3	4	5	6
		Action plan on safety audit analysis	1	2	3	4	5	6
2	Safety documents	Communicate to personnel	1	2	3	4	5	6
		Review safety document	1	2	3	4	5	6
		Provide up-to-date safety documents	1	2	3	4	5	6
3	Pre-tender assessment	Carry out pre-tender risk assessment	1	2	3	4	5	6
		Communicate H&S plan to site	1	2	3	4	5	6
		Review finding in H&S plan	1	2	3	4	5	6
4	Accident/incident reporting procedures	Communicate procedures to personnel	1	2	3	4	5	6
		Trained personnel to take reporting details	1	2	3	4	5	6
		Conduct investigation on all reports	1	2	3	4	5	6
		Reporting analysis	1	2	3	4	5	6
		Review repeated occurrence	1	2	3	4	5	6
5	Near miss reporting procedures	Communicate procedures to personnel	1	2	3	4	5	6
		Trained personnel to take reporting details	1	2	3	4	5	6
		Conduct investigation on all reports	1	2	3	4	5	6
		Reporting analysis	1	2	3	4	5	6
		Review repeated occurrence	1	2	3	4	5	6
6	Safety policy	Communicate safety policy to personnel	1	2	3	4	5	6
		Policy relates to company objectives	1	2	3	4	5	6
		Review safety policy where necessary	1	2	3	4	5	6
7	Safety meeting with supervisors	Planned meeting once a week	1	2	3	4	5	6
		Discuss work progress, H&S issues	1	2	3	4	5	6
		Record attendance	1	2	3	4	5	6
		Review any substandard work/incidents	1	2	3	4	5	6
		Communicate actions highlighted during meeting to relevant persons	1	2	3	4	5	6
		Senior management involvement	1	2	3	4	5	6
8	Safety meeting with sub-contractors	Planned meeting once a week	1	2	3	4	5	6
		Discuss work progress, H&S issues	1	2	3	4	5	6
		Record attendance	1	2	3	4	5	6
		Review any substandard work/incidents	1	2	3	4	5	6
		Communicate actions highlighted during meeting to relevant persons	1	2	3	4	5	6

No	Sub-factors	Indicators	absolutely essential	very important	important	of little importance	not important	don't know
9	Choose competent sub-contractors	Communicate company H&S expectation to prospective sub-contractors	1	2	3	4	5	6
		Sub-contractors submit H&S requirement during pre-tender stage	.	2	3	4	5	6
		Pre qualification ability questionnaires	1	2	3	4	5	6
10	Health & Safety Committee (HSC)	HSC from all level of personnel	1	2	3	4	5	6
		HSC responsible for company safety performance		2	3	4	5	6
		Review & evaluate company procedures & implementation	1	2	3	4	5	6
11	Safety officer (SO)	Full time (> 75%) on project	1	2	3	4	5	6
		SO competent & trained	1	2	3	4	5	6
		Responsible for training, advice & inspection	1	2	3	4	5	6
		Responsible for all reporting of accident/incident and near misses	1	2	3	4	5	6
12	Induction course	Induction for all personnel on first day of work	1	2	3	4	5	6
		Comprehensive course content	1	2	3	4	5	6
		Not more than one working day length	1	2	3	4	5	6
		Use written material & visual aid	1	2	3	4	5	6
		Carry out evaluation after induction	1	2	3	4	5	6
13	Inspection	Planned inspection	1	2	3	4	5	6
		By competent supervisors	1	2	3	4	5	6
		Assess risk before commencing work	1	2	3	4	5	6
		Review any substandard performance	1	2	3	4	5	6
		Follow-up defines who, how and when	1	2	3	4	5	6
14	Tool-box talk	By competent supervisor	1	2	3	4	5	6
		Talk on particular work	1	2	3	4	5	6
		Frequency of talk	1	2	3	4	5	6
		Review task, method statement & work permit	1	2	3	4	5	6
		Carry out assessment before work commences	1	2	3	4	5	6
		Initiate action on all sub-standard situations	1	2	3	4	5	6
15	Construction risk analysis	Communicate construction H&S plan	1	2	3	4	5	6
		Carry out safety briefing before work commences	1	2	3	4	5	6
		Review risk analysis with respective workers		2	3	4	5	6
		Revise the analysis if necessary		2	3	4	5	6
16	Method statements	Communicate method statement to respective workers	1	2	3	4	5	6
		Conduct formal training if required	1	2	3	4	5	6

No	Sub-factors	Indicators	absolutely essential	very important	important	of little importance	not important	don't know
17	Permit-to-work	Design risk assessment to identify type of permit required	1	2	3	4	5	6
		Permit to be issued by trained & appointed person	1	2	3	4	5	6
		Incorporate method statement with permit-to-work	1	2	3	4	5	6
18	Machinery & equipment in safe working condition	Trained/skilled operators	1	2	3	4	5	6
		Machinery manuals are in place & in use	1	2	3	4	5	6
19	Good housekeeping	Planned storage area by reference to construction programme	1	2	3	4	5	6
		Outside & inside storage area	1	2	3	4	5	6
		Conduct housekeeping checks	1	2	3	4	5	6
		Daily clean-up	1	2	3	4	5	6
20	Material safety & health data sheet (MSDS)	Communicate MSHDS to affected personnel	1	2	3	4	5	6
		Training for hazardous material	1	2	3	4	5	6
		Review & up-to-date MSHDS if required	1	2	3	4	5	6
		HQ to keep master copy of MSHDS	1	2	3	4	5	6
21	Emergency response system	Communicate emergency system to all	1	2	3	4	5	6
		Provide training for emergency situation	1	2	3	4	5	6
		Carry out drills	1	2	3	4	5	6
22	Procedures for recommendation, suggestion or improvement	Communicate procedures to all personnel	1	2	3	4	5	6
		Reward personnel who had given any proposal, suggestion or improvement	1	2	3	4	5	6
		Communicate all accepted proposals	1	2	3	4	5	6
23	Procedures for conveying instruction	Clear chain of command throughout the project	1	2	3	4	5	6
		Communicate instruction during meeting	1	2	3	4	5	6
		Instruction can be verbal or written	1	2	3	4	5	6
24	Safety boards, signs, guarding & posters	Communicate safety message through posters & boards	1	2	3	4	5	6
		For signs & guarding, follow standard codes and colours	1	2	3	4	5	6
		Posters and boards must be seen by everyone at least once a day	1	2	3	4	5	6
		Place safety poster at entrance	1	2	3	4	5	6
		Change safety posters at least a fortnightly	1	2	3	4	5	6

No	Sub-factors	Indicators	absolutely essential	very important	important	of little importance	not important	don't know
25	Safe behaviour	Communicate the message of safety as important	1	2	3	4	5	6
		Safe behaviour exists on site	1	2	3	4	5	6
		Safe behaviour related to equipment, tools & machinery	1	2	3	4	5	6
26	Safe working environment exists	Management to provide safe & conducive working environment	1	2	3	4	5	6
27	Proper health care	All personnel entitled to proper medical care & attention	1	2	3	4	5	6
		Formal procedures to monitor industrial hygiene	1	2	3	4	5	6
		Pre-employment questionnaire	1	2	3	4	5	6
28	Motivation	Encourage active participation of personnel in decision making	1	2	3	4	5	6
		Reward good safety performance	1	2	3	4	5	6
		Implement appraisal system	1	2	3	4	5	6
29	Right person for the right job	Personnel have the right skill and knowledge	1	2	3	4	5	6
		Reference from previous employer	1	2	3	4	5	6
		Probationary period for new personnel	1	2	3	4	5	6

APPENDIX 8.1 – LIST OF SCMS

APPENDIX 8.1

GUIDELINES FOR IMPROVEMENT OF SAFETY CONTROL MEASURES FOR SPMT

8.1 SAFETY CONTROL MEASURES (SCMs)

The following details explain the 'best practice' for each thirty SCMs. These 'best practice' details were gathered from current practices and literature reviews and will be used as guidelines to improve safety performance on site. Management can refer to these guidelines when planning remedial actions for the weaker SCMs or for better performance on SPMT. The following are the explanation for each SCM.

8.2.1 Safety Audit

The performance of both systems and people constantly changes and in general deteriorates unless something is done to maintain it. To combat this an auditing process is developed with a two-fold purpose: to maintain performance and to ensure relevance and effectiveness. Clarke (1999) states that auditing provides management with further information on compliance with standards. Meanwhile Cox et al (1996) states that auditing can be distinguished from inspection and routine monitoring in that it provides an objective and formally documented overview of the whole management system. Devised externally or in-house, the audit process must be carried out by trained, competent persons outside the department or activity being audited. Glendon et al (1995) described six types of safety audit:

a) safety audits on specific topics, for example human factors, hazardous substances or environments;
b) plant technical audits involve an in-depth review of all plant and process carried out by specialist staff, for example on a five-yearly basis;
c) the site technical audits cover all work of specified types at predetermined intervals and involve both local and specialist staff;
d) compliance audits (or verification audits) are designed to establish whether the range of relevant health and safety legal requirements have been complied with by the organisation;
e) validation audits are concerned with both the scope of an audit and its design - focus upon such matters as whether the right kind of sub-systems and components are being adopted, whether the right kind of monitoring is being done and whether appropriate sub-systems are in place; and
f) management safety audits (or area safety audits) are typically carried out annually and usually cover general matters involving local staff and perhaps specialist auditing staff as well.

Audits are undertaken for the following reasons:

- to measure safety performance;
- to provide an indication of safety priorities;
- to pinpoint weakness;
- to identify training needs and to assess workforce commitment/apathy; and
- to ensure responsibilities are understood.

8.2.2 Up-to-date safety documents

In order to perform safely, SPMT assumes that it is essential for the management to convey all the relevant safety documents to the respective personnel with communication taking place during both the pre-construction and construction phases.

Safety documents are required by the Construction (Design and Management) (CDM) Regulations 1994. The CDM Regulations aim to ensure that all relevant information regarding the project is available during the pre-construction phase. An example of such a document is the pre-tender Health and Safety Plan for the appointment of contractors. This information must be up-dated to help the prospective contractors know the risk involved with the project. From here the successful contractor will have to prepare a construction Health and Safety Plan for the project.

The safety documents during the construction phase are numerous. All respective personnel need to gather the right safety documents before proceeding with the tasks. There are safety documents that are for everyone like the safety policy while some safety documents are for specific tasks like method statements.

Whatever the level of work is, the management has to ensure all the safety documents whether from the HQ management or from the site management must be updated when necessary. The relevant authorities must communicate any changes to any safety documents as soon as possible.

8.2.3 Pre-tender risk assessment

In construction the process of designing is separate from the process of building and constructing. This separation goes beyond to the root of construction difficulties. Designing and building have become two separate processes. Since 1995, they have been regulated by two aspects to risk assessment, namely:

- CDM Regulations which require designers to risk assess the design of construction and management arrangements to be made (see Section 4.3.3); and
- the Management Regulations which require contractors to risk assess the way in which they intend to carry out construction on site.

The CDM regulations require designers to:

- identify hazards in their designs;
- identify risks arising from hazards; and
- eliminate, reduce or control the risks they have created.

Clarke (1999) agrees that design is the starting point for any construction process. The design defines the work to be carried out and very often can be crucial in determining how it is to be carried out. Designers will sometimes refute this suggestion, pointing out that contractors are free to decide how to execute the construction once they are awarded a contract, but frequently the design must be assembled in a particular order and sequence that effectively limits contractors to a few, or even a single methodology. The designer is best placed to understand and manage this.

Clarke continues to argue that designers can do more to eliminate hazards and risks at the drawing board than the contractor on site. At the end of the day, the design risk assessment information is presented under the pre-tender Health and Safety Plan. The purpose of the pre-tender plan is to inform prospective contractors of the unusual design hazards, together with the project-wide health and safety arrangements to be made by those who have designed and managed the design to date.

In practice, taking into account the various contractual arrangements, designers can include any and all of the following:

- architects and engineers, civil, structural and others;
- mechanical, electrical and public health engineers designing building services;
- interior designers, landscape architects, shop fitters and the like; and
- quantity surveyors and other surveyors and specifiers; main contractors and specialist contractors either developing consultants design for the permanent works or designing temporary works including formwork, falsework and scaffolding.

The pre-tender plan should contain comprehensive information about unusual risks contained in the design, to the extent that they may not be readily apparent in the tender arrangements, or similar proposals, to a competent principal contractor. It is not necessary to identify all risks, merely those which are unusual and which are created by the design. These include drawings, design details, specification and bills of quantities.

The pre-tender Health and Safety plan is set out under nine separate headings:

- nature of the project;
- the existing environment;
- existing drawings;
- the design;
- construction materials;
- site-wide elements;
- overlap with client's undertaking;
- site rules; and
- continuing liaison.

8.2.4 Accident/incident reporting system

The requirements for the reporting of accidents in all areas of employment are defined in the Reporting of Injuries, Disease and Dangerous Occurrences Regulations (RIDDOR 1995). Made under Section 15 of the HSWA, RIDDOR relates to all accidents occurring in any employment in the UK and lay down details of reporting and recording (Ridley 1994). SPMT expects the company to inform all personnel about the system for reporting of accidents/incidents. This can be done during the induction training for all new employees on the jobsite. Firstly the company needs to explain what type of accidents/incidents needs reporting and these are as follows:

Fatal accidents

Fatal accidents must be reported if they arise either out of or in connection with work whether the person who dies is employed or not.

Accidents causing injury or illness

These are the type of accidents that must be reported when a person suffers a major injury at work or a certain type of illness that requires medical attention. This would include fracture of the skull, any bone, amputation of any part of the hand, loss of eyesight, loss of consciousness and admission to hospital for more than 24 hours or any other injury resulting in an ability to work for more than 3 days.

Disease

This requires the reporting of any disease contracted as a result of work. The diseases are split into five groups as follows: poisoning, skin disease, lung disease, infections mainly from animals or handling human tissue and other conditions such as malignant diseases.

Gas incidents

There is a requirement which places a duty on suppliers of gas, whether through a fixed pipe or refillable containers, to report immediately to the management any incidents resulting from the use of their product that causes any of the above injuries.

Dangerous occurrence

There are five situations where reporting is compulsory under this heading:

- general situations such as electric short circuit, collapse of scaffolding;
- dangerous occurrences which are reportable in relation to mines;
- dangerous occurrences which are reportable in relation to quarries;
- dangerous occurrences which are reportable in respect of relevant transport systems; and
- dangerous occurrences which are reportable in respect of an offshore workplace.

The company must also introduce the correct types of form to be filled in for each accident/incident. The policy of the company should be to emphasise that every accident or injury, of any kind at any level, must be reported immediately to the supervisors, specialist-contractor management or site management. All serious accidents must be investigated. The accident investigation procedure begins as soon as all immediate danger to people and property has been brought under control and the relevant authorities have been informed. The investigation should be conducted by the safety officer or site management. Its purpose is to secure and confirm as many facts as possible - not to place blame. Bird et al (1993) suggested that the accidents/incidents investigation procedures should be as follows:

- identify all individuals who were in the vicinity of the accident immediately prior to or during the accident;
- photograph the complete accident area and if possible, videotape it;
- summarise and analyse the causes of the accident;
- prepare an investigation report;
- inform management and head office of the result of the investigations; and
- inform personnel of the result of the accidents during meetings or toolbox talks.

8.2.5 Near miss reporting system

A near miss is a situation where the sequence of events that could have caused an accident if it has not been interrupted. Any near miss incident, no matter how slight, must be reported to the management. The management should inform all personnel on site about the company near miss reporting system - the types of forms to fill in, the location of the forms and the personnel in charge.

The management must emphasise that all reporting of near misses is not to find fault or to place blame on anyone, but rather to find the cause and to prevent reoccurrence. All near miss situations must be investigated and it is here that management is able to improve the situation and make it safer. All personnel must be informed of the outcome of any investigation and all actions taken to make a situation safer must be highlighted.

8.2.6 Safety policy

One of the major recommendations of the Robens Report (see Ridley (1994) for details of this report) was that all employers should develop and publish a statement setting out their intentions with regard to protecting the health and safety of their employees (Ridley 1994). This is now enshrined in the HSWA Section 2(3), which states that all employers must have a written statement of their safety policy.

The safety policy should be made known to all employees either by displaying it on notice boards or by giving each employee a personal copy. In addition, the induction training should include a discussion of the company's safety policy. Supporting the policy should be information about the organisation that exists to implement the policy and the facilities or arrangements that are in place for achieving the policy's intent (Ridley 1994).

The company safety policy should provide information and strategies for the following:

- safe working environment to perform all company activities in a manner that reduces risk to all employees and to all other workers;
- all office equipment and jobsite conditions maintained in a way that eliminates risk to visitors and the public and eliminates risk of damage to property and equipment;
- providing safe, well maintained equipment, proper training for all equipment operators, and instruction on safe methods and procedures;
- complying with all national and local law and regulations as they apply to all work performed; and
- refusing to accept any unsafe working conditions for any reason, and to take immediate corrective action when any safety violation is observed.

8.2.7 Meetings with supervisors

Meetings allow different supervisory groups to gather and discuss safety matters with the managers and through these, suggestions, feedback and planning can be aired.

Some of the meetings are regularly scheduled while some may be held for special purposes. In addition meetings foster good communication and co-operation among those attending the meetings.

The agenda for each meeting may include the following:

- Attendance;
- report of the company safety record and current company-wide safety programme;
- discussion of current safety issues affecting ongoing company projects;
- review of any near miss incidents;
- how they occurred;
- possible affects;
- suggestion for improvements to the safety programme;
- training issues if required;
- suggested toolbox topics; and
- notification of any changes or new information affecting the ongoing work.

8.2.8 Meetings with specialist-contractors

Janandi (1996) suggested that for best practice in safety the frequency of *meetings* with specialist-contractors should be at least once a week with management parties including the site management team, the supervisors, the specialist-contractors and whenever possible the representative from HQ. The agenda will generally discuss similar items to those in meetings with supervisors with focus placed on the specialist-contractor's performance. At the end of the day, the following must be obtained:

- a review of accidents and incidents;
- a forum for the discussion of safety problems with specialist-contractor team members;
- a review of operating and maintenance procedures; and
- a checklist in response to evaluation *of ongoing activities.*

8.2.9 Choosing competent specialist-contractors

Specialist-contractor selection is the first step in the process of being sure that specialist-contractors contribute to the improvement of safety performance of the project. Management must ensure that only those specialist-contractors who put safety as a high priority are employed. Levitt et al (1993) proposed that a safety evaluation for this purpose could be based upon two kinds of data:

a) Data about a contractor's past safety record which provides an objective prediction of its future performance. These can be obtained from insurance measures, post-accident data and references from past clients. The data can be obtained from RIDDOR that gives the incidence rate for accidents such as fatality, non-fatal injury rate and over three day injury rate. References from past clients will provide better information about the specialist-contractors safety attitude and safety culture on the jobsite.

b) Data about the contractor's current safety practices which provides a current but more subjective prediction of its future safety performance.

The specialist-contractors must also demonstrate that they have proof of their own safety documentation as follows:

Accountability for accidents
This is to determine whether the specialist-contractor's management has established a system under which supervisors at all levels are held accountable for their subordinates' accidents.

Safety training
This is to find out how the specialist-contractors carry out their training programme. The training materials will provide objective evidence in support when doing an evaluation.

Formal safety programmes
The specialist-contractors have to produce an original, written statement of their safety programme to hand out to employees in order to demonstrate their concern for safety.

Safety meetings
Specialist-contractors could show evidence of carefully planned and documented toolbox talks and/or meetings with supervisors. Samples of meeting materials or minutes from a meeting might be the basis for additional points in detailed selection.

8.2.10 Health and Safety Committee (HSC)

The HSC is made up of both employer and employee representatives who are charged with the responsibility of general oversight of the project safety programme. Civitello (1998) listed the main function and responsibilities of the HSC as follows:

a) to meet regularly to review the company's overall safety programme, and specific operating issues that may arise during the period;
b) to serve in an advisory capacity to the safety manager and the line management;
c) to familiarise themselves with applicable construction safety standards;
d) to review established company procedures and evaluate the effectiveness of their implementation;
e) to recommend corrections and improvements in procedures, safety rules, and company policies with respect to accidents and illness prevention;
f) to communicate company procedures approved by management to all employees and ensure all updates and changes to company procedures, as approved by management, are adopted and properly co-ordinated within the entire company safety programme;
g) to participate in communication procedures by which the company shall train committee members and employees: and
h) to prepare and distribute the minutes of committee meetings and make records of committee activities and communications available to all employees.
i) senior managers are present to approve decisions and to indicate priority given to health and safety;

j) safety adviser's role to be ex-officio advisory to all members; equal member opportunity to contribute agenda items;
k) membership should reflect representation within the organisation;
l) regular meetings at pre-arranged dates; maintain good minutes;
m) in larger organisations, separate committees should represent individual work areas; above these should be a co-ordinating committee which deals with issues of concern to more than one work area that cannot be resolved within local committees;
n) generally, health and safety matters should be dealt with close to the scene of action where the response can be immediate; follow up recommendations should concentrate upon important issues;
o) committee members should be firmly committed to the objective of improving health and safety and setting high standards for achievement;
p) regular attendance of all members is important in facilitating the development of solid relationships;
q) effective health and safety training should be provided for all members; and
r) the committee should be compact and of a manageable size.

8.2.11 Safety Officer

The company safety officer is responsible for the administration and routine dissemination of all company safety programmes and for monitoring the compliance of the company employees with all stated policies and procedures. The safety officer will assist the project manager and site supervisors in all matters pertaining to safety and loss control. Civitello (1998) and Levitt et al (1993) listed out the duties of the safety officer to include but not be limited to:
a) assist each company employee with compliance with the company health and safety policies and regulations;
b) implement the company safety programme and monitor compliance;
c) co-ordinate all company safety activities in ways that facilitate their implementation;
d) advise on the purchase of health and safety materials to ensure compliance with all safety standards;
e) advise management regarding proposed and/or necessary changes in safety standards and regulations;
f) conduct field inspections in efforts to identify unsafe conditions and/or actions of jobsite personnel - make verbal and written recommendations for both immediate and future correction, follow up to assure correction and issue warnings of persistent, uncorrected unsafe conditions;
g) organise and conduct training of supervisory and hourly employees in safe work procedures;
h) be thoroughly familiar with applicable rules and regulations for this knowledge and assist the management with interpretations, development of policy and implementation of all adopted procedures;
i) represent the management during inspections;
j) co-ordinate the deployment of emergency care systems, such as first aid, medical, fire protection, evacuation and fire alarms;
k) be knowledgeable of health-related and hygiene-related activities, and pursue continuing education with respect to them;

l) co-ordinate any/all site security procedures and personnel, when required for a specific project;
m) assist site management in the implementation of safety programmes.
n) co-ordinate jobsite meetings among site management, supervisors and specialist-contractors;
o) co-ordinate the organisation's emergency procedures;
p) review all accident/incident and near miss reports for lesson learnt;
q) co-ordinate and participate in disciplinary actions and procedures; and
r) carry out safety performance assessments and periodic evaluation of safety performance.

8.2.12 Induction training

Orientation or induction to the project should involve all levels of personnel - management, supervisors, operatives and specialist-contractors. The management cannot take for granted that new workers automatically know what to do on a job. According to Levitt (1993) skilled and well-trained workers still cannot know the particular hazards and problems of a construction project new to them. For this reason, management must treat every employee as a new employee even if the person has worked for the company or the site manager before.

New workers need a chance to get their bearings and learn some of the basic requirements early on. On a small job. the job-site manager or the general foreman can give new workers a short tour. The management gives the new workers an immediate indication of what is important on the project.

A slide tape or video presentation can provide new employees with an overview of the company project requirements and the project setting, as well as demonstrating how to deal with special hazards. Slide shows or videos are only one of the many types of orientation materials used during induction training. Simple booklets for new employees, emphasising management's concern for safety and describing company and project work rules. The supervisor should carry out an induction programme follow-up to make sure that questions can be answered and comments made after a week of the induction training.

8.2.13 Inspections

Each worksite must be regularly analysed on a continuous basis in order to identify existing actual or potential hazardous conditions. Site inspections to be carried out in order to identify the health and safety responsibility of all supervisors to regularly observe jobsite, work areas, tools and equipment daily. Inspections can identify appropriate actions necessary to eliminate or control any hazards. Bird et al (1992) suggested that a well managed inspections programme can meet goals such as these:

- identify potential problems;
- identify equipment deficiencies;
- identify unsafe actions;
- identify effects of changes; identify inadequacies in remedial actions;
- provide management self-appraisal information; and

- demonstrate management commitment.

There are three types of inspections:
- informal inspections;
- planned inspections; and
- general inspections.

Informal inspections
Informal inspections, when properly promoted and utilised can spot many potential problems as changes occur and work progresses. However despite this, they have many limitations too in that they are not systematic and some even fail to follow-up any sub-standard situations. Nevertheless, having an informal inspection in addition to a planned inspection helps in pinpointing defects, unsafe conditions and unsafe behaviour.

Planned inspections
No managers or supervisors should leave inspections to chance and a system should be managed in order to prevent loss as a result of critical parts/items. The planning of inspections should include the following:
- critical parts/items inspections including making an inventory; record keeping and pre-equipment checks; and
- housekeeping evaluations.

General inspections
The general inspection is normally a planned walk-through of an entire area. Bird et al (1992) reported that general inspections have the following advantages:
- inspectors devote full attention to the inspection, not done as something incidental to operational work;
- inspectors prepare their eye to be observant and their minds to be perceptive;
- checklists are used as guides to ensure that a thorough inspection has been made;
- the inspectors carry out more detailed and thorough inspections; and
- report findings and recommendations are made to increase hazard awareness, corrective actions and accident prevention measures.

When the chance of loss is high, inspections can help to keep control and frequent general inspections add assurance that the risks are under control. Bird et all (1992) suggested the following steps to carry out inspections be observed:
Prepare
- start with a positive attitude;
- plan the inspection;
- determine what to look at;
- know what to look for;
- make checklist; and
- review previous inspection reports.

Inspect
- refer to the map and checklist;
- accent the positive;
- look for off-the floor and out-of-the-way items;

- take immediate temporary actions;
- describe and locate each item clearly;
- classify the hazards;
- report items that seem unnecessary; and
- determine the basic cause of sub-standard actions and conditions.

Develop remedial actions
- take follow-up actions

Inspection report
- reports are important for feedback on areas of safety problems;
- reports must be distributed to relevant personnel upper and middle management;
- reports must communicate hazards, substandard situations and practices;
- reports document all actions so efforts are not repeated; and
- reports prompt follow-up actions and give continuity between inspections.

8.2.14 Toolbox talks

Toolbox talks are one type of meeting, which site managers should consider as part of the job-site communication system. Highly effective managers make sure that the talks are directed towards the work to be undertaken and the right kind of toolbox talk can make a vital difference in safety performance. Toolbox talks are essentially a two-way interchange with workers and therefore provide a valuable information how a task can be implemented. In their study. Levitt et al (1993) concluded that successful managers treat toolbox talks as a continuing method to inform, train and hear from workers, rather than as regulation-mandated rituals. These short meetings form another means of keeping communications with regard to safety, quality and all other aspects of the job flowing to and from job management. This toolbox talk is another way of involving personnel in project operations.

Bird et al (1992) reported that it is important that topics covered in safety talks are carefully selected well in advance of a meeting, thus ensuring that important time is given to critical topics rather than spur-of-the-moment ideas. Each topic selected should be directly related to the people involved – their exposures, their problems, their concerns and their needs.

Levitt et al (1993) state that supervisors or specialist-contractors usually run the weekly toolbox talks and the following points will help to improve them:
- issue weekly safety newsletters, which feature relevant topics for the supervisors or specialist-contractors to use if they do have a specific topic;
- organise a planning group of supervisors to develop a series of suggested topics that can be distributed;
- organise training sessions for supervisors to help them improve their skills in conducting toolbox talks; and
- develop checklists or reminder sheets for toolbox talks.

Levitt et al describe the following methods to help the supervisors conduct good toolbox meetings:

Prepare
Prepare what to talk about. Don't just wait until the last minute.

Pinpoint
Keep it simple. Don't try to cover too much ground. Keep the talk short and simple (around 10 minutes) – 'zero in' on one main idea.

Personalise
Establish common ground with the listeners. Get real interest, bring it close to home and make it mean something to the listeners, make it important to them.

Picturise
Create a crystal-clear mental picture of your listeners. The safety talk is a form of communication. Make the talk mean something to the listeners.

Prescribe
In closing the talk, always answer the questions that your listeners have in mind. Tell them what you want them to do. Give them a prescription.

8.2.15 Construction risk assessment

Although the risk assessment philosophy has been in place since 1974, it was not put to practical effect until 1992 when the Management Regulations were introduced (Clarke 1999). The essential elements of risk assessments are that they must be suitable and sufficient, they must deal with likelihood and severity, and embrace all those involved in or who are affected by the work activity being assessed. If more than five persons are involved, these assessments must be in writing. Clarke (1999) listed five steps to be taken in carrying out risk assessments and they are:

- identify hazard;
- assess risk;
- apply the hierarchy of risk control;
- monitor and review; and
- audit.

The statutory definitions of hazards and risk are the minimum standards, which all employers and those self-employed must achieve. Before a risk assessment can be carried out, it is necessary to consider carefully, and in some detail, the method of work to be adopted as well as any alternatives.

Once appointed by the Client, a contractor must produce a health and safety plan before starting work on site. The principle contractor must then take into account this pre-tender Health and Safety Plan when doing the risk assessment. They must set out in reasonable detail the intended arrangements, the resources allocated to dealing with the unusual design risks and other issues set out under the nine separate headings stated in the pre-tender Health and Safety Plan. The contractor must:

- set out the project-wide arrangements for managing health and safety issues on site;
- the contractor must deal with specific risks arising from the specialist-contractor's proposed methods of work; and

- the contractor must deal with any other health and safety issues arising out of, but directly connected with the intended work method.

The construction health and safety plan is intended to be used by those actually carrying out the work on site and should therefore be prepared with this in mind.

8.2.16 Method statements

Method statements are an important safety factor that affects safety performance on sites. To support this decision, Clarke (1999) gave the following reasons for method statements:

- getting a contractor to write things down and make them think about the task in hand;
- it encourages contractors to commit to what they are writing;
- it helps communicate the planner's thoughts and intentions to operatives;
- it serves as a basis for co-ordination and planning with other activities; and
- it establishes an audit trail.

There is no set format for method statements, however they must be able to compile a sufficient risk assessment of the way the contractor proposes to work. There is a link between method statements and risk assessments. The essence of good method statement writing as suggested by Clarke is as follows:

- it should state what is to be done;
- it should describe how it is to be done;
- it should specify the time scale allowed;
- it should indicate the labour, plant and materials to be used;
- it should describe any work sequence or relationship to preceding or succeeding activities; and
- it should take into account the contractor's risk assessment.

8.2.17 Permit to work system

A permit to work system is a formal control system designed to prevent accidental injury to personnel, damage to plant, premises and product, particularly when work with a foreseeable high hazard content is undertaken and the precautions required are numerous and complex. Permit to work is essentially a document that sets out the work to be done and the precautions to be taken. It predetermines safe drills and is a clear record that all foreseeable hazards have been considered and all precautions are defined and taken in the correct sequence. It does not in itself make the job safe, but is dependent for its effectiveness on special persons carrying it out conscientiously and with a high degree of supervision, control and training of staff.

The permit to work system must be formal, but also simple to operate, so as to ensure the commitment of those who operate and who are affected by it. Ridley (1994) cited the following as essential elements of permit to work systems:

a) the permit must provide concise and accurate information about who is to do the work, the time span over which the permit is valid, specific work to be undertaken and precautions;

b) the area in which the work is to be carried out is clearly identified and made safe, or the hazards are highlighted;
c) the management must sign and be responsible for all work that requires necessary isolation, blanking off, etc, has been completed and it is safe for workmen to enter the area;
d) the workmen must sign the work permit to say that they fully understand the work that is to be carried out, the limitations of access and the hazards and potential risks to be faced;
e) any monitoring required before, during and after the work must be specified and the results noted on the documents;
f) when the work is completed, the workers must sign off the permit to say they have completed the specified work and left the work area in a suitable state; and
g) the management must sign to accept that the work has been completed.

The format of a work permit will be determined by the particular type of work being undertaken, however all such documents should cover the seven points mentioned above.

8.2.18 Machine and equipment in working condition

Machine and equipment reliability and operating efficiency are no accident. Civitello (1998) claims that by following simple rules of observation and reasonable care will reduce equipment down time, thereby increasing operating efficiency and improving operator well being. The operator or a designated competent person must make a safety inspection of the equipment to be used prior to each work shift. Any condition found that could result in unsafe operation must be corrected before continuing. Civitello (1998) had listed in details rules related to hand tools, power tools and power-activated tools and rules that relate to heavy equipment and trucks.

8.2.19 Housekeeping

Housekeeping means keeping everything at work in its proper place and ensuring that things are correctly stored after use. According to a study by Civitello (1998) the housekeeping responsibilities fall on every employee to see that their immediate work area is free from housekeeping hazards that might cause slips, trips, falls, fires, health hazards, electrical hazards, etc. Similarly, each employee should be looking out for small hazards while walking from place to place during their daily work activities. Employees should correct or report any such hazard at once. The jobsite should be maintained in such a manner that no debris is allowed to accumulate in or cluster work areas, walkways, stairs, ladders, aisles, doorways, etc. Formwork and scrap timber with protruding nails and all other debris should be kept clear from work areas. All combustible scrap and debris must be removed at regular intervals and covers are required for flammable or harmful substances. Glass containers should not be permitted on jobsites. Each employees is responsible for clean up of all debris from their own areas before moving on to the next phase of work

Housekeeping also applies to storage areas. All storage areas should avoid crossflow of traffic and minimise movement. Items of stock should be grouped generally into those that are frequently in demand and those that are less in demand, placing the former nearer to the point of issue. The location of material should be planned by reference to the construction programme, allowing alternative use of space as soon as possible but making sure another delivery of the previous material is not imminent.

Any particular valuable perishable or hazardous material should receive special attention and be located where they can be more secure and frequently supervised by the storekeeper. Utilisation of available height in storage should be given to proper stacking, and the use of shelves, racks, pallets appropriate to the materials. Where storage area is not covered, resurfacing with additional hard-core or concrete should be a priority task where deep ruts or potholes have developed. Use of equipment as listed below will allow more effective available space:

- bins for small items;
- racks;
- pallets; and
- tubular steel stand.

8.2.20 Material Safety and Health Data Sheet (MSHDS)

MSHDSs provide each employee with specific information on chemicals that they may use or come in contact with during the course of their employment. The safety officer should maintain the manual and be responsible for acquiring and updating the MSHDS, contacting the chemical manufacturer vendor if additional research is necessary, or if no MSHDS was provided with the initial shipment of the respective material. A master list of MSHDS should be available from the safety officer and the head-office management. Civitello (1998) states that each MSHDS must include at least the following information:

- chemical identity;
- hazardous ingredients;
- physical and chemical characteristics;
- fire and explosion hazard data;
- reactivity data;
- health hazards;
- precautions for safe handling and use; and
- control measures.

8.2.21 Emergency response system

Emergency procedures must be planned before work commences such that general precautions are in place from the start. Types of emergency are as follows:

- accidents involving serious injury or death;
- property damage accidents;
- public demonstration;
- fire; and
- bomb threats.

Some emergencies may require evacuation of the site, while others might involve the rescue of an injured person. In the book 'Successful health and safety management', HSE (1996) had that when planning emergency procedures, routes and exits must take into account:

- the type of work being done on site;
- the characteristics and size of the site and the number of and location of workplaces on the site;
- the plant and equipment being used;
- the number of people likely to be present on the site at any one time; and
- the physical and chemical properties of substances or materials on or likely to be on the site.

8.2.22 Suggestions system

Soliciting comments from workers is an excellent idea and can be achieved through a suggestion system which can be informal or formal in approach. The informal approach is through direct contact and verbal communication and can be done either by the person or through a team leader or union leader. The formal approach is through a hotline e.g. suggestion box, suggestion forms or the site canteen.

All suggestions require follow-up action in order to encourage future suggestions for safety and other work improvements. If they are not acted on, through adoption, a report must be produced on why it was unfeasible. Levitt et al (1993) claimed that no response from management is the quickest way to throttle participation. The following is the best way for the management to have good communication at all levels on a project:

a) frankness with management;
b) establish genuine two-way communications between all levels of management. when critical situation is choked off at higher levels of the company, it ceases to flow at lower levels;
c) supervisor accessibility;
d) develop awareness among managers that the keys to better listening are accessibility and responsiveness. employees do not want to be heard at all times but when they do have a problem, they need assurance that their supervisor will listen and act;
e) welcoming the new and different;
f) tolerate all kinds of ideas – those that are silly, foreign or hostile as well as those that management considers constructive and looking with disfavour on employees for thinking differently leads to close minds;
g) visible benefits;
h) visibly reward those who have creative new ideas - this is the strongest encouragement management can give;
i) acceptance of criticism;
j) regard criticism as healthy and normal and lack of criticism can be dangerous and undesirable - an indication that employees have given up trying to get through to management;
k) sensitivity to the employee; and
l) be willing to wrestle with problems of interpreting what an employee is really trying to say - an employee's gripe about working conditions may mask a belief that the supervisor does not appreciate in his or her job performance.

8.2.23 Communication

Companies that are leaders in safety are those which have effective communication between management and personnel, whereby the leaders discuss safety programmes and safety performance with employees. On site it is important for the project to have a good communication system between the management, supervisors and workers.

According to Levitt et al (1993), it is essential for employees to regularly receive information on the following:
- the costs, frequency and type of accidents;
- the hazards of the operation they perform and safe methods of operations;
- the goals for safety performance and unit standings; and
- the safety rules.

Most of the communication process results from what happens every hour of every day, in the one-on-one ongoing regular relationship between the worker, his or her supervisor and the management. Formal communication is far less important than informal interaction. According to Levitt et al (1993), three factors influence the effectiveness of communication - its credibility, its attractiveness and its power (or control). Employees generally have clear-cut ideas about their company's safety activities. The methods, the goals and the amount of vigour and sincerity they reflect, as well as the way workers view company safety effort, strongly influence the employee's safety behaviour on the job. In addition, the ability to learn from and respond to safety media (poster, films, booklets) is directly dependent on employee perception of management's interest.

a) Contacts include safety meetings, one-to-one discussions, and other means used by supervisors and management to communicate. Safety contacts can take the forms of one-on-one discussions or occur in a meeting format. Although safety meetings are traditional, they may be less effective than one-on-one interactions. This category measures employee perception of contact effectiveness. Success in each case depends upon the skill of the team leader or supervisor.

In order to ensure smooth flow of communication, Peterson (1996) provided the following checklist:

The message
What is it supposed to be? What language is it to be put in? What information does it contain?

Communicators
Who are they? What are their roles? Where do they stand on the status scale? Is there a status gradient?

Media
What form should it be? What are the mechanics of the information handling? What is the density of the communication system? What is the time pattern?

The environment
What are the circumstances of the communication? Are they appropriate on this occasion? What about the situational factors, specifically who must know the information?

Effects
How effective is the system? How capable is it of adoption? What is its aim?

8.2.24 Safety promotion

Printed materials such as bulletins, posters, statistical reports, booklets, magazines and newsletters can be used effectively to promote health and safety and also both supplement and reinforce other promotional activities.

Bulletins and posters
Be first to know the content of the current posters and bulletin board materials. Encourage the employees to read them. Stimulate interest by referring to the safety promotions in group meetings and personal contacts. Ask personnel what they think the message is, what it means and why it is important. See that posters and bulletin boards are kept neat and up-to-date.

Magazines and newsletters
These usually reach a large majority of employees and their families. The materials will contain health and safety items, report accidents/incidents and lessons learnt from them and inform as to what is being done to promote safety and healthy working conditions.

Statistical reports
Statistics report can be more creative and easily understood by all. Use aids to create clear mental pictures of what the losses mean in terms of people, property, production and profits.

Signs
Signs and symbols warnings of hazardous jobsite conditions are to be visible at all times when work is being performed and are to be removed or covered promptly when the hazards no longer exist. Types of signs include:

- danger signs;
- caution signs;
- exit signs;
- safety instruction signs;
- directional signs; and
- traffic signs.

8.2.25 Safe behaviour

The goal of safe, productive work can best be served by the management stressing safety. Workers on a new job want to know what is expected of them and what the real priorities are. Levitt et al (1993) argued that everything about the job must reflect

the message of safety clearly. Very successful managers make the communication of safety to the entire workforce their first task on a new project and know that reaching every single worker is necessary. Only when the workers know that safety comes first will they make their decisions so that each job is done in a safe manner.
Each individual must also have safety in mind in order to continue operating safely under constantly changing conditions. Equipment posing hazards – cranes, trucks, and earth moving equipment – are frequently moving on site, unlike for manufacturing where potentially hazardous equipment is permanently stationed and surrounded by engineered guards. For this reason, safety is more emphasised on construction jobsites.

The management must always keep everyone's attention on safety. A statement about priorities is embedded in every action which the manager takes at every stage of project life. Keeping safety in the forefront of each person's mind is a continuing, never-ending job throughout the project. One way that site managers can demonstrate their commitment to safe project performance is through empowering employees to stop work if they consider it would be unsafe to continue. The employee then reports his or her actions to the immediate supervisor.

8.2.26 Safe working environment

Company must establish a safe and effective working environment as regulated by the legislation and employers are responsible to ensure that minimum requirements for a safe working environment must be met on all construction sites regardless of the size.

Physical conditions in the workplace support safe work and there is a requirement for employers to adequately assess and control the risks associated with all hazards. However it is also important to ensure that the physical environment is routinely monitored and reviewed as part of an ongoing maintenance of the safety system.

Workstations should be arranged so that each task can be carried out safely and comfortably. The worker should be at a suitable height in relation to the work surface and work materials and frequently used equipment or controls should be within easy reach, without undue bending or stretching. Each workstation should also allow any person who is likely to work there adequate freedom and movement and also be free from obstructions or clutter. Workplace assessment should recognise common risks such as slipping, tripping and falling.

Besides workstations, employers must also provide adequate welfare facilities for all personnel. The following are the summary requirements set by the Management of Health and Safety at Work Regulations 1992.

Welfare facilities
Companies to provide the following:
- Sanitary conveniences;
- Washing facilities;
- Drinking water; and
- Facilities for rest.

Fresh air
Steps have to be taken so as to ensure the workplace has sufficient fresh or purified air.

Temperature and weather protection
Suitable and sufficient steps should be taken to ensure that during working hours, the temperature at any indoor place of work to which these regulations apply is reasonable, having regard for the purpose for which that place is used. Every place of outdoor work is to be arranged so that protection is provided from adverse weather.

Lighting
Provide suitable lighting at workplaces and all traffic routes.

Good order
All parts of any construction site which are used as a place of work are to be kept in good order and in a reasonable state of cleanliness.

8.2.27 Training

Bird et al (1992) described six steps to successful employee training:
- pinpoint training needs;
- set training objectives;
- decide how best to meet the training objectives;
- secure and/or develop the training programme;
- carry out training; and
- evaluate and follow-up the training.

Pinpoint training needs
There are many ways to evaluate performance and pinpoint the training needs of personnel. Observations give a systematic way to compare the person's performance with the standard job procedures and practices. Management can also carry out tests in order to analyse the training needs of individuals. These may be knowledge tests (either verbal or written), performance tests or both. In addition surveys are often used for identifying training needs either in the form of structured interviews or written questionnaires. All of these approaches help the management to identify the training needs of its personnel on site.

Set training objectives
Nothing is more important than clear, specific objectives to which all training should aim. They encompass the task, the instructor, the learner, the course content and the on-the-job performance and should be learner-oriented rather than teacher-oriented. What is important is what the learner will learn at the end of the day.

Decide how best to meet the training objectives
After finding out the training needs and setting the objectives, it is necessary to examine the various training methods. The trainers should ensure that effective methods are applied during training sessions such as videos, slides, written materials, discussions, exhibits and others. The main idea is to pick the 'who-where-when-what-and how' approach. 'Who' means who will administer the training? 'Where' means

where will the training be conducted? 'When' means when will the training start? 'What' means what written materials are required, what equipment and facilities are needed and lastly 'how' means how much of training will be theory, how much is practical, how will the trainers be selected?

Secure and/or develop the training programme
At this stage, the trainer is clear as to what is required in order to carry out an effective training class. The trainer needs to ensure that the following are prepared:
- the lesson plans;
- the visual and/or audio aids;
- the passouts and study material;
- the facilities; and
- the tools, machine or equipment.

Carry out training
The following procedures will enhance the training sessions:
- prepare properly;
- communicate clearly;
- promote participation; and
- reinforce rapport.

Evaluate and follow-up the training.
All training programmes should be evaluated to determine the degree to which the objectives were met and how the programmes can be improved. To test the knowledge of the trainees, carry out formal and informal testing with the trainees. Informal testing could be through observations, performance feedback, or discussions.

8.2.28 Proper health care

According to Civitello (1998), every employer has a duty to provide adequate health care for all employees on site. This information is conveyed during the induction training at the beginning of the appointment on the jobsite. Management must keep the medical information of all personnel. This information can be obtained through the pre-employment medical questionnaire. This information will be useful during any emergency to know the victim's medical history.

He adds that clearly marked 'FIRST AID' boxes must be provided and put in the charge of a responsible person whose name must be displayed near the box. After assessing the level of risk, the availability of emergency services and other matters, it can be determined whether a trained and certified first aider is required. Where there is a large workforce on a site suitably staffed and equipped, a first-aid room should be provided. However, when there is a large workforce on site, it is suitable to provide on site medical facilities instead of seeking treatment outside. Regardless of the number of employees provision should be made for every employee to have reasonably rapid access to first aid. Ensure that telephone communication is available on site during safety or medical emergency. For sites that do not have permanent telephones, management must make sure mobile phones are available in close proximity at all times.

8.2.29 Motivation

Most types of motivation are based on personal needs. Peterson (198) discussed various management thinking such as conflict theory, motivation-hygiene theory and Likert theory that relates to employees motivation. Neale (1979) and Mansfield et al (1991) agree that motivation for the construction industry must look at the characteristic of the industry such as short-term employment, types of contract and others. For motivation techniques to have an impact on employees, it must recognise that different individual with different need, behaviour and types of reward they prefer. Mansfield et al listed six types as follows:

- rational-economic man – motivated by economic incentives;
- social man – motivated by social need associated with others;
- self-actualised man – self-motivated and self-controlled;
- complex man – mixture of three of the above; and
- psychological man – complicated and unfolding.

Significant motivators in the construction industry are as follows:

Employees attitude

New jobs often creates stress, it is recommended that new employees should be given special attention before they develop poor working habits. This can be achieved through orientation programme that familiarise the new employees with the organisation and provide them with a feeling of security and value.

Achievement

To develop employees into 'achievers', they must be given tasks that are suited with their skills and knowledge.

Appreciation

The nature of construction project provides management and workers excellent opportunities for appreciation thus satisfying their reputation and recognition. This will create obligation for high standard of performance

Responsibility

Giving responsibility to employees keep them interested in their jobs and allow satisfaction of self-fulfilment need.

Money

Monetary reward as a motivator has always created controversy. Some researchers have opted not to link the effect of money with performance of employees. Others have agreed that money is another way of motivating employees towards better performance.

Advancement

Short-term nature of construction projects lessens the opportunity for promotion and advancement in the organisation. Thus advancement can be achieved via rewarding staff with special assignments or new responsibilities, transferring them to new jobs or sending them for courses or training.

Participation

Participation satisfies many needs such as recognition, affiliation and acceptance.

Competition
Implementing competition in construction projects opens up the way for individuals with distinguished qualities to put their potential to the fullest.

Social relationship
Construction managers can potentially achieve better results by promoting social relationships at work. The development of good social environment encourages good working co-operation.

8.2.30 Recruiting the right person

It is important to ensure that only the right person is appointed for a particular job in order to reduce accidents/incidents. Management must handle new workers as suggested by Civitello (1998):

a) ask about the last job
management can gather this information through application forms and interviews - by asking the right questions, management will be able to find out their past experience and skills in great detail; this information guides the management in deciding on initial job assignment and possible supplementary on-the-job training;
b) describe the new job and the job rules
from the beginning, the management must make it clear that safety is an integral part of their work rules;
c) show the workers around the site
a tour of the whole site will give the opportunity to point out the layout and major job hazards;
d) start the workers by doing a trial on the job
start the workers not with the regular assignments but something lighter - this is to allow management to pay attention to them especially with regard to safety;
e) involve the crew in watching out for the new worker
the management should involve the other crewmembers in the job of watching out for the new worker. Crews with safer records make a point of keeping an eye on new members. Such concern for the new workers are has shown to decrease accident numbers;
f) probationary period for the new workers; and
ensure all new workers are put on a probationary period and this may vary from three months to three years - this period provides the management with the flexibility to remove any new employees that are not abiding by the company safety rules and regulations and by the end of the probationary period, the management will make a decision as to whether he or she will be employed on a permanent basis.

APPENDIX 9.1 - SPMT PAPER VERSION

Project name ....

Address ....

Date ....

Job description *(please tick the relevant box)*

HQ management	✓
Site management	
Site supervisor	
Site operatives	
Specialist sub-contractors	

Please state 'trade' ***(e.g. steelwork, brickwork, electrical services etc.)*** ....

Instructions:

Please answer from your own experience.
If you are not sure, please leave the box blank.
You are not being tested and the results of SPMT do not include the names of any of the people involved.

4 5

No	Indicators	Answer
1a	Does the HQ organise safety audits?	
1b	Does the HQ staff participate in safety audits?	
1c	If Yes, have you received any pre-audit training?	
1d	How often do you carry out safety audits? *(tick only one box)*	
	• more than once a year	
	• every once a year	
	• every 6 months	
	• every 4 months	
	• every 3 months	
	• every month	
	• less than once a month	
1e	Does the HQ staff carry out safety analyses?	
1f	Do you send any analyses and feedback to site management?	
1g	Do you develop any action plan based on safety audit analyses?	
2a	Do you provide up-to-date safety documents for the project? (e g bulletins, directives, etc)	
2b	Do you review safety documents at least once throughout the project?	
2c	Do you inform and advise the project on any changes regarding the safety documents?	
3a	Is there a system for reporting near miss?	
3b	Are personnel trained to undertake reporting of near misses?	
3c	Do you receive any feedback of analyses on near misses from site?	
3d	If yes, how often do you receive the feedback? *(tick only one box)*	
	• every week	
	• every fortnightly	
	• every three weeks	
	• every month	
	• more once a month	
4a	Do the company have own system for reporting accidents/incidents?	
4b	Do the reporting system for accidents/incidents recording any of the following *(tick each box that applies)*	
	• Fatality	
	• Lost days cases	
	• Doctor's cases	
	• First-aid cases	

HQ

No	Indicators	Answer
	• Property damage	
	• Environmental damage	
4c	Are personnel trained to undertake reporting of accidents/incidents?	
4d	Do you receive any analysis of accidents/incidents from site?	
4e	If yes, what is the frequency? *(tick only one box)*	
	• Every week	
	• Every fortnightly	
	• Every three weeks	
	• Every month	
	• More than once a month	
5a	Do you carry out risk assessments for the following? *(tick each box that applies)*	
	• site layout	
	• design layout	
	• working environment	
5b	Do you communicate the health & safety plan to personnel?	
5c	Is there a link between the Planning Supervisor, Principal Contractor and Specialist-Contractors?	
6a	Does the project have its own safety policy?	
6b	Do the safety policy relates to the following? *(tick each box that applies)*	
	• company objectives	
	• company expectation with regard to safety	
6c	Does board of directors endorse the safety policy?	
6d	Is the safety policy distributed to site? *(tick each box that applies)*	
	• before project commences?	
	• after the project commences??	
6e	Is the safety policy reviewed at least once throughout the project?	
7a	Do you choose only competent specialist-contractors?	
7b	Do you communicate the company's h&s definition to prospective specialist-contractors?	
7c	Are the prospective Specialist-contractors required to submit health and safety competent records at the pre-tender stage?	
7d	Do you carry out a pre-qualification ability questionnaire on the specialist contractors?	

No	Indicators	Answer
8a	Do you ensure that your safety officer spends at least 75% of the time on site?	
8b	Is the Safety Officer competent and trained?	
8c	Is the safety officer responsible for the following? *(tick each box that applies)*	
	• Training, advice and inspection?	
	• Overseeing all reporting of accidents/incidents and near misses	
	• Carry out safety performance evaluation	
9	Do the HQ management keep the latest up-dated master copy of MSHDS (material safety and health data sheet)	
10	Do you have a clear chain of command among HQ management, site management, supervisors, operatives and specialist-contractors?	
11	Is all the training on site conducted by qualified and competent personnel?	
12	Does the company provide proper health care for all its employees?	
13a	Do you ensure only the right personnel are appointed for the right job?	
13b	For managerial and line management position, do you carry out objective data and interview of personnel to assess the competency level?	
13c	Is a probationary period observed for the new personnel?	

4'6

Project name ....

Address ....

Date ....

Job description *(please tick the relevant box)*

HQ management	
Site management	✓
Site supervisor	
Site operatives	
Specialist sub-contractors	

Please state 'trade' ***(e.g. steelwork, brickwork, electrical services etc.)*** ....

Instructions:

Please answer from your own experience.
If you are not sure, please leave the box blank.
You are not being tested and the results of SPMT do not include the names of any of the people involved.

No	Indicators	Answer
1a	Do you participate in safety audits?	
1b	If yes, did you receive any pre-audit training?	
1c	Do you receive a safety audit analyses and feedback from HQ after every audit?	
1d	Do you develop any action plan based on the safety audit analyses?	
2a	Have you received safety documents from HQ e.g. safety checklist, safety bulletin, etc	
2b	Has HQ informed of any changes/reviews of the existing documents?	
2c	Has HQ provided up-to-date safety documents for this project to replace the generic safety documents?	
3a	Have you been provided with the pre-tender Safety Plan for your project?	
3b	Has the hazards raised in the document been incorporated into your construction phase safety plan?	
4a	Have you informed project personnel about the project's system for reporting of accidents/incidents?	
4b	If yes (to 4a), when did you inform personnel? (tick only one box)	
	• Before or during the induction course	
	• Only after an accident/incident had occurred	
4c	Do you record all reports of accidents/incidents?	
4d	How often do you carry out investigation analysis? (tick only one box)	
	• more than a week	
	• once a week	
	• once a fortnightly	
	• once every three weeks	
	• once a month	
	• less than once a month	
4e	How often do you review the frequency of repeated accidents/incidents cases? (tick only one box)	
	• more than a week	
	• once a week	
	• once a fortnightly	
	• once every three weeks	
	• once a month	
	• less than once a month	

No	Indicators	Answer
4f	Who do you distribute feedback of accidents/incidents investigation analysis findings to? (tick each box that applies)	
	• HQ	
	• Supervisors	
	• Operatives	
	• Specialist-contractors	
4g	When do you distribute feedback of accidents/incidents investigation analysis? (tick each box that applies)	
	• Daily inspections	
	• Weekly site meetings	
	• Tool-box talks	
	• No specific time	
5a	Have you informed project personnel of the project's system for reporting near misses?	
5b	If yes (to 5a), when did you inform personnel? (tick only one box)	
	• Before or during the induction course	
	• Only after a near miss had occurred	
5c	Do you record all reports of near misses?	
5d	How often do you carry out analysis on near miss reporting? (tick only one box)	
	• more than a week	
	• once a week	
	• once a fortnightly	
	• once every three weeks	
	• once a month	
	• less than once a month	
5e	How often do you review the frequency of repeated near miss cases? (tick only one box)	
	• more than a week	
	• once a week	
	• once a fortnightly	
	• once every three weeks	
	• once a month	
	• less than once a month	

No	Indicators	Answer
5f	Who do you distribute the analyses of repeated near misses to? (tick each box that applies)	
	• HQ	
	• Supervisors	
	• Operatives	
	• Sub-contractors	
5g	When did you distribute feedback of near miss investigation analyses? (tick each box that applies)	
	• Daily inspections	
	• Weekly site meetings	
	• Tool-box talks	
	• No specific time	
6a	Do you distribute the safety policy to all personnel on the project?	
6b	When did you distribute the safety policy? (tick only one box)	
	• Any time before & during the induction training	
	• After the induction training	
7a	Do you have a Health and Safety Committee on site?	
7b	Does the Health and Safety Committee have representatives from the following levels? (tick each box that applies)	
	• management	
	• supervisors	
	• operatives	
	• sub-contractors	
7c	Which of the following operations is the Health and Safety Committee responsible for? (tick each box that applies)	
	• general oversight of the project's safety performance	
	• review the general safety performance and specific operating issue that may arise during the period	
	• familiarise themselves with applicable construction standards	
	• recommend corrections and improvements in procedures, safety rules and company policies with respect to accidents/incidents	
	• communicate procedures approved by management to all personnel	
	• develop company wide action plans for compliance with safety regulations	
	• involvement in developing action plan for project accountability	

4r6

No	Indicators	Answer
	• provide suggestions and direction for efficient implementation of prescribed corrective measures	
8a	Do you conduct planned meeting at least once a week with supervisors?	
8b	Do you record attendance at planned meetings with supervisors?	
8c	During the meetings with supervisors, do you discuss any of the following? (tick each box that applies)	
	• progress of work	
	• safety issues	
	• substandard performance by operatives and sub-contractors	
	• recommendation for any action plan to overcome this substandard performance	
8d	Do you carry out review with the supervisors on any of the following? (tick each box that applies)	
	• Any sub-standard work situations	
	• Action plans on near misses & accidents/incidents occurrences	
8e	Do you communicate any actions/information reported during meetings to the respective operatives?	
9a	Do you conduct planned meetings at least once a week with specialist-contractors?	
9b	Do you record attendance at meetings with specialist-contractors	
9c	During the meetings with specialist–contractors, do you discuss any of the following? (tick each box that applies)	
	• progress of work	
	• safety issues	
	• substandard performance by sub-contractors	
	• recommendation for any action plan to overcome this substandard performance	
9d	Do you review any sub-standard work situations with supervisors?	
9e	Do you distribute minutes of meetings to specialist-contractors?	
10a	Does your Safety Officer spend at least 75% of his time on the project?	
	Is project Safety Officer trained and competent?	
	Is the Safety Officer responsible for the following? (tick each box that applies)	
	• advise regarding safety	
	• safety training on site	
	• site inspection	
	• accident/incident reporting	
	• near misses reporting	

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No	Indicators	Answer
	• review of investigation analysis	
	• carry out performance evaluation on site	
11a	Do you conduct induction training for all personnel?	
11b	Does the induction training covers the following? (tick each box that applies)	
	• safety rules	
	• safety policy	
	• safety regulations	
	• personnel rights and responsibilities	
	• overview of company procedures	
	• site management hierarchy	
	• introduction of personnel to their supervisors	
	• notification of emergency plan	
	• location of medical and emergency aid	
	• site layout	
	• housekeeping arrangements	
	• permit-to work systems and method statements	
	• reporting system for accidents/incidents	
	• reporting system for near misses	
	• explain security system, issue of passes and permits	
11c	Is there any form of proof of induction training?	
11d	Is the induction training in one working day?	
11e	Do you carry out a tour of the work place noting exits, dangers etc as part of the induction training??	
11f	Do you use written material and visual aids to conduct induction training?	
11g	Do you give proper instructions regarding PPE e.g. instruction on how to wear it or look after it, etc.?	
11h	Do you hand out appropriate safety booklets to all attendees at the end of the induction training?	
11i	Do you carry out verbal or written evaluation at the end of the induction training?	
12a	Are the inspections carried out by competent supervisors?	
12b	Do the supervisors receive any risk assessment training before hand?	
12c	Do you receive analysis reports of repetitive substandard performance from supervisors?	
12d	Do you ensure risk assessment is carried out where required?	
12e	Do you communicate the analysis report of risk assessments for future orientation and training programme?	

No	Indicators	Answer
13a	Do you identify critical working areas that have inherent difficulties or significant risks in their execution?	
13b	Do you produce method statements for the identified critical working areas that have the inherent difficulties or significant risks?	
13c	Do you identify individual who are responsible to ensure compliance with the method statements prepared?	
13d	Do you provide formal training for the critical job identified?	
13e	Do you make sure that method statements are detailed enough to provide the correct sequence of work description of the critical job identified?	
13f	Do you ensure contingencies are planned for in case the method statements do not work accordingly?	
	.	
14a	Do you make sure that a permit to work is provided for all work that involves risks?	
14b	Regarding work permits, are the following being observed? (tick each box that applies)	
	• Design risk assessments to identify type of permit required	
	• Permit issued only by appointed and trained personnel	
	• Permit properly authorised and accepted before work commences	
	• Only issuers or identified management supervisors can cancel, alter or override the permit	
	• Permits always identify hazards and establish precautions needed	
	• Permits incorporated in method statements to ensure work is carried out safely	
15a	Do you ensure that only trained/skilled personnel handle machinery and tools?	
15b	Do you ensure that all machinery manuals are in place for the operators or maintenance department to use?	
16a	Do you emphasise good housekeeping on the project?	
16b	Are planned storage areas designed as follows? (tick each box that applies)	
	• storage areas planned by reference to the construction programmes	
	• items stocked according to their demand, placing the former nearer to the point of issue	
	• no cross flow of traffic and minimise movement	
	• all perishable, hazardous and valuable materials receive special attention, more secure and frequently visited by storekeeper	
	• hazardous material stocks on site are minimised	
	• items such as bins, pallets, racks and proper lighting are used to allow more effective use of available space	
	• where storage area is not covered, resurfacing and proper drainage is essential	

4IP

No	Indicators	Answer
	• housekeeping racking checks are made	
	• clean-up is completed daily	
17a	Do have MSHDS (material safety health data sheets) on all hazardous material?	
17b	Do you communicate MSHDS to all affected personnel?	
17c	Do you review and up date MSHDS when required?	
18a	Do you implement an emergency response system on site?	
18b	Do you inform all personnel of the necessary actions to be taken during an emergency?	
18c	Is training provided for all personnel involved with hazardous substances?	
18d	Do you carry out emergency drills at least once during the project?	
19	Do you provide the following channels to make recommendations, safety suggestions or improvements?	
i	Informal system e.g. verbal, opinion leaders	
ii	Formal system such as: (tick each box that applies)	
	• suggestion box	
	• suggestion forms/notice boards	
	• union representative	
19b	Do you announce to all personnel any suggestion had been accepted and who suggested it?	
19c	Do you reward personnel who had given any proposal, suggestion or improvement?	
19d	Are all recommendations, suggestions or improvements followed by a written communication from management?	
19e	Do you review all safety suggestions or recommendations made by personnel?	
20a	Do you have a clear procedure for conveying instruction?	
20b	Does a clear chain of command exist among management, site management, supervisors, specialist-contractors and operatives?	
20c	Do you communicate instructions during meetings?	
20d	Do all instructions include both the following? (tick each box that applies)	
	• verbal	
	• non verbal	
21a	Do you communicate safety message through safety boards, safety poster, safety signs, etc?	
21b	Do you ensure that the signs follow standard colours and codes?	

No	Indicators	Answer
21c	When placing the safety posters, do you consider the following? (tick each box that applies)	
	• Place at entrance	
	• Must be seen by everyone at least once a day	
21d	Do you change safety posters at least once a fortnight?	
22a	Do you provide proper medical facilities to all personnel on site e.g. first-aid?	
22b	Do all personnel complete a pre-employment medical questionnaire?	
22c	Does the site have at least one qualified first-aider?	
23a	Do you ensure that training is provided where required?	
23b	Does your training programme include any of the following? (tick each box that applies)	
	• Induction	
	• Pre-audit training	
	• Training for undertaking reporting of accident/incident and near misses	
	• Emergency response system	
	• Training for high risks job	
	• Training for handling hazardous material	
	• Risk assessment training	
23c	Do you carry out the following assessment for training? (tick each box that applies)	
	• Formal assessment	
	• Informal assessment	
24a	Does the management set attainable safety goals for personnel to achieve?	
24b	Does the management encourage active participation of personnel in decision making?	
24c	Do you reward good safety performance?	
24d	Does the existing appraisal system recognise good safety performance	
25	Do you ensure that the right personnel have the right skill and knowledge to carry out the job?	

Document Check

Please check all the related documents stated below and tick if they are available on site

No	Indicators	
1	Updated safety document	
2	Health and Safety plan.	
3	Accident/incident reports	
4	Near miss reports.	
5	Safety policy endorsed by board of directors	
6	Minutes of meeting with supervisors	
7	Attendance record for meeting with supervisor	
8	Attendance record for meeting with specialist-contractors	
9	Copy of substandard work report to specialist-contractor and management	
10	Record of tool-box talk	
11	Master copy of MSHDS (material safety & health data sheet)	
12	Training record for all personnel	
13	Sample of work permits for high risk jobs	
14	Method statements should be detailed and comprehensive	

Document check

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Please fill in the boxes after an observation had been carried out.
Only 100% compliance is considered a 'YES'.

No	Indicator	Answers
1	Safety policy displayed in conspicuous place	
2	Identification for all those who had attended the induction course	
3	Open storage area	
4	Closed storage area	
5	Daily clean up is carried out everyday	
6	Formal system for making safety suggestions, recommendations or improvements on site e.g. suggestion box, suggestion forms/notice boards or union representative.	
7	Safety posters and signage on site communicate message of safety	
8	Signage and posters using simple language	
9	Safety score board to highlight safety targets e.g. total safe working hours etc	
10	Location of poster must be seen by all personnel at least once during the working day	
11	At least one safety poster at entrance	
12	Check if the following are observed regarding PPE ' tick only if 100% compliance)	
	• all personnel wear it voluntary	
	• all personnel use only steel-toed shoes or safety boots	
	• all personnel use the right PPE whenever appropriate and required	
	• all PPE must suits the wearer in terms of size & height	
	• personnel to return used or damaged PPE and receive a re issue	
	• management to ensure that safety shields and guards are in place and secured prior to commencement of equipment operations.	
13	Regarding tool, machinery and equipment, check if the following are observed:	
	• only trained and skilled operators are allowed to handle equipment, tool and machinery '	
	• all equipment properly stored and maintained – clean and safe for operations.	
14	Observe if the following working environment is provided throughout the site. (tick only if 100% compliance)	
	• proper guards and supports	
	• proper illumination	
	• proper ventilation	
	• work place not congested	
	• all tools and equipment in working condition	
	• orderly work place	
	• proper warning and detection style	
	• suitable and sufficient welfare facilities	

Observation

Project name ....

Address ....

Date ....

Job description *(please tick the relevant box)*

HQ management	
Site management	
Site supervisor	✓
Site operatives	
Specialist sub-contractors	

Please state 'trade' *(e.g. steelwork, brickwork, electrical services etc.)* ....

Instructions:

Please answer from your own experience.
If you are not sure, please leave the box blank.
You are <u>not</u> being tested and the results of SPMT do <u>not</u> include the names of any of the people involved.

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No	Indicators	Answer
1a	Do you participate in safety audits?	
1b	If yes, did you receive any pre-audit training?	
2a	Do you know about the project's system of reporting of accidents/incidents?	
2b	If yes, when were you told about it? *(tick only one box)*	
	• Anytime before or *during the* induction course	
	• Only after an accident/incident had occurred	
2c	After an accident had occurred, when did you begin to conduct the investigation?	
	• On the same day	
	• On the following day	
	• After two days	
2d	Do you convey feedback about the analyses of accidents/incidents investigations to management?	
3a	Do you know about the project's system for reporting near misses?	
3b	If yes, when were you informed? *(tick only one box)*	
	• Anytime before or during the induction course	
	• Only after the a near miss had occurred	
3c	After a near miss had occurred, when did you begin to conduct the investigation?	
	• On the same day	
	• On the following day	
	• After two days	
3d	Do you convey feedback about the analyses of near miss investigations to management?	
4a	Did you receive the project's safety policy?	
4b	When is the safety policy given to you? *(tick only one box)*	
	• Any time before or during the induction training	
	• After the induction training	
5a	Do you have planned meeting at least once a week with site management?	
5b	Are the following items being discussed during planned meetings with site management? *(tick each box that applies)*	
	• Progress of work	
	• safety issues	
	• review substandard performance by operatives	
	• recommendations and suggestions for any action plan to overcome this substandard performance	

No	Indicators	Answer
5c	Do you review action plans or near misses & accidents/incidents?	
6a	Did you attend induction training on your first day on site?	
6a	Does the induction training cover the following? *(tick each box that applies)*	
	• safety rules	
	• safety policy	
	• safety regulations	
	• personnel rights and responsibilities	
	• overview of company procedures	
	• site management hierarchy	
	• introduction of personnel to their supervisors	
	• notification of emergency plan	
	• location of medical and emergency aid	
	• site layout	
	• housekeeping arrangements	
	• permit-to work systems and method statements	
	• reporting system for accidents/incidents	
	• reporting system for near misses	
	• security system, issue of passes and permits	
6c	Did you receive some proof of attendance after attending the induction training?	
6d	Did the induction training last for not more than one working day?	
6e	Did the site management conduct a tour of the work place noting exit, dangers etc?	
6f	Did the site management use written materials and visual aids to conduct induction training?	
6g	Did you receive proper advice regarding PPE (personal protective equipment), during induction e.g. instruction on how to wear it or how to look after it, etc.?	
6h	Did you receive a safety handbook which is appropriate to you at the end of the induction training?	
6i	Was an evaluation carried out at the end of the course either verbal or written?	
7a	Did you carry out toolbox talk as follows? *(tick each box that applies)*	
	• Daily for pre-task	
	• Weekly for general safety	
7b	Do the talk focus on gang's particular work	
7c	Do the talk last no more than 10 minutes?	
7d	Do you record all toolbox talks?	

No	Indicators	Answer
8a	Do you review tasks, method statements and work permits with workforce during the toolbox talks?	
8b	Do you carry out risk assessment before work commences?	
8c	Do you initiate actions on all substandard situations?	
9a	Do you carry out planned inspections at least once a day?	
9b	Did you receive any risk assessment training before hand?	
9c	Do you plan your inspections as follows?: *(tick each box that applies)*	
	• review applicable regulations related to ongoing work	
	• know the hazard involved with high risk jobs	
	• choose specific route and be prepared to divert during inspections	
	• use checklist	
9d	Do you assess risk for the following jobs?	
	• Inspect scaffold, working platforms and personal suspension equipment according to the regulations	
	• Inspect excavations which required support before work commences according to the regulations *(if no excavation exist, please tick the box)*	
	• Inspect plant and equipment which could affect safety of the workplace	
	• Initiate action on all substandard conditions and practices spotted during inspections	
	• Produce reports on all substandard situations either in a standard form or daily/weekly report	
	• Issue substandard work reports given to respective specialist-contractors or operatives for remedial action	
9e	Do you review any repetitive sub-standard performance?	
9f	Do all acceptable follow-up define the following?	
	• person carrying out the task	
	• time scale to complete the remedial task	
	• the right way of carrying out the task	
10a	Do you refer to the project health and safety plan?	
10b	Do you review risks with respective workers before work commences?	
10c	Carry out safety briefing before work commences?	
10d	Do you review the risk analysis and revise if necessary?	
11	For hazardous material, is appropriate training in handling and safe use of the material provided?	

No	Indicators	Answer
12a	Does a clear chain of command: exist among HQ management, site management, supervisors, specialist-contractors and operatives?	
12b	Do you receive work instructions from management during meetings e.g. daily meetings or weekly meetings?	
13a	Do you know about the informal system for making recommendations, safety suggestions or improvements e.g. verbal or union leaders?	
13b	Do you know about the formal system where personnel are encourage to make safety suggestions, recommendations or improvements such as: *(tick each box that applies)*	
	• suggestion box	
	• suggestion forms	
	• union representatives	
13c	Has the company ever announced any suggestions that had been accepted and who suggested them?	
14	On this project, have you attended any of the following training programmes? *(tick each box that applies)*	
	• Induction	
	• Pre-audit training	
	• Training for undertaking reporting of accident/incident and near misses	
	• Emergency response system	
	• Training for high risks job	
	• Training for handling hazardous materials	
	• Risk assessment training	
15a	Are the goals set by management attainable?	
15b	Do the management encourage active participation of personnel in decision making?	
15c	Are you rewarded for good safety performance?	
15d	Does the existing appraisal system recognise good safety performance?	
16a	Do you receive any medical facilities on this project e.g. first aid?	
16b	Did you complete a pre-employment medical questionnaire?	

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Project name ....

Address ....

Date ....

Job description *(please tick the relevant box)*

HQ management	
Site management	
Site supervisor	
Site operatives	✔
Specialist sub-contractors	

Please state 'trade' ***(e.g. steelwork, brickwork, electrical services etc.)*** ....

Instructions:

Please answer from your own experience.
If you are not sure, please leave the box blank.
You are <u>not</u> being tested and the results of SPMT do <u>not</u> include the names of any of the people involved.

No.	Indicators	Answer
1a	Do you participate in safety audits?	
	(This is where the safety procedures are checked periodically throughout the project)	
1b	If yes, did you receive any pre-audit training?	
2a	Do you know about the project's system of reporting of accidents/incidents?	
2b	If yes, when were you told about it? *(tick only one box)*	
	• Anytime before or during the induction course	
	• Only after an accident/incident had occurred	
2c	After an accident had occurred, did you receive feedback about the analysis of accident/incident investigation from management?	
2d	When did you receive the feedback of accidents/incidents investigation analyses? *(tick only one box)*	
	• Daily inspections	
	• Weekly site meetings	
	• Tool-box talks	
	• No specific time	
3a	Do you know about the project's system for reporting near misses?	
3b	If yes, when were you informed? *(tick only one box)*	
	• Anytime before or during the induction course	
	• Only after the a near miss had occurred	
3c	After a near miss had occurred, did you receive feedback about the analyses of investigation from management?	
3d	If yes, when did you receive the feedback of near miss investigation analyses? *(tick one box only)*	
	• Daily inspections	
	• Weekly site meetings	
	• Tool-box talks	
	• No specific time	
4a	Did you receive the project's safety policy?	
4b	When is the safety policy given to you? *(tick only one box)*	
	• Any time before or during the induction training	
	• After the induction training	
5	Is MSHDS (material safety health data sheet) provided for all personnel with specific information on chemicals that the personnel will come in contact with?	

No.	Indicators	Answer
6a	Are you informed of the necessary action to be taken during an emergency?	
6b	Is training required for all personnel who involve to hazardous substances?	
6c	Did you participate in drills at least once during the project?	
7a	Did you attend induction training on your first day on site?	
7a	Does the induction training cover the following? *(tick each box that applies)*	
	• safety rules	
	• safety policy	
	• safety regulations	
	• personnel rights and responsibilities	
	• overview of company procedures	
	• site management hierarchy	
	• introduction of personnel to their supervisors	
	• notification of emergency plan	
	• location of medical and emergency aid	
	• site layout	
	• housekeeping arrangements	
	• permit-to work systems and method statements	
	• reporting system for accidents/incidents	
	• reporting system for near misses	
	• security system, issue of passes and permits	
7c	Did you receive some proof of attendance after attending the induction training?	
7d	Did the induction training last for not more than one working day?	
7e	Did the site management conduct a tour of the work place noting exit, dangers etc?	
7f	Did the site management use written materials and visual aids to conduct induction training?	
7g	Did you receive proper advice regarding PPE (personal protective equipment), during induction e.g. instruction on how to wear it or how to look after it, etc.?	
7h	Did you receive a safety handbook which is appropriate to you at the end of the induction training?	
7i	Was an evaluation carried out at the end of the course either verbal or written?	
8a	Do you know about the informal system for making recommendations, safety suggestions or improvements e.g. verbal or union leaders?	
8b	Do you know about the formal system where personnel are encourage to make safety suggestions, recommendations or improvements such as *(tick each one that applies)*	
	• suggestion box	

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No.	Indicators	Answer
	• suggestion forms	
	• site canteen	
8c	Has the company ever announced any suggestions that had been accepted and who suggested them?	
9a	Does a clear chain of command: exist among HQ management, site management, supervisors, specialist-contractors and operatives?	
9b	Do you receive work instructions from management during meetings e.g. daily meetings or weekly meetings?	
10a	Do you receive any medical facilities on this project e.g. first aid?	
10b	Did you complete a pre-employment medical questionnaire?	
11a	Do you work in a safe working environment?	
11b	There is a continuous message that no job is so important that safety is overlooked?	
11c	Do you know the company safety rules and procedures?	
11d	How often do you comply with the rules and procedures? *(tick only one box)*	
	• All the times	
	• Sometimes	
	• Never	
11e	How often do you follow the directions given by management or supervisors? *(tick only one box)*	
	• All the times	
	• Sometimes	
	• Never	
11f	Regarding PPE (personal protective equipment), do you...... *(tick each box that applies)*	
	• wear because you are concerned about safety?	
	• wear it voluntarily?	
	• use only steel-toed shoes or safety boots?	
	• ensure safety shields and guards are in place and secured prior of commencement of equipment operations?	
	• use the right PPE whenever appropriate and required?	
	• Always get PPE that suits you in terms of size & height?	
	• receive training on how to use it?	
	• return used or damaged PPE and receive a reissue	

No.	Indicators	Answer
11g	Regarding tool, machinery and equipment, do you........... *(tick each box that applies)*	
	• know where safety equipment is and how to use it correctly?	
	• only handle equipment, tool and machinery when you are trained?	
	• store and maintain all equipment – ensure they are clean, safe in operation?	
	• return the equipment to the sores if condition is unsafe?	
11h	On this project, have you taken any of the following actions before? *(tick each box that applies)*	
	• reported any substandard working condition or suspected of being unsafe to the supervisor	
	• reported any near miss or incident/accident to supervisors, no matter how slight it seems?	
	• stop work if you felt it was unsafe to continue?	
12a	Are the goals set by management attainable?	
12b	Do the management encourage active participation of personnel in decision making?	
12c	Are you rewarded for good safety performance?	
12d	Does the existing appraisal system recognise good safety performance?	
13	On this project, have you attended any of the following training programmes? *(tick each box that applies)*	
	• Induction	
	• Pre-audit training	
	• Training for undertaking reporting of accident/incident and near misses	
	• Emergency response system	
	• Training for high risks job	
	• Training for handling hazardous materials	
	• Risk assessment training	
14	Does the working environment provide the following? *(tick each box that applies)*	
	• proper guards and support	
	• proper illumination	
	• proper ventilation	
	• work place not congested	
	• all tools and equipment in working condition	
	• orderly work place	
	• proper warning and detection style	
	• suitable and sufficient welfare facilities	

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Project name ....

Address ....

Date ....

Job description (*please tick the relevant box*)

HQ management	
Site management	
Site supervisor	
Site operatives	
Specialist sub-contractors	✓

Please state 'trade' (*e.g. steelwork, brickwork, electrical services etc.*) ....

Instructions:

Please answer from your own experience.
If you are not sure, please leave the box blank.
You are not being tested and the results of SPMT do not include the names of any of the people involved.

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No.	Indicators	Answers
1a	Do you participate in safety audits?	
1b	If yes, did you receive any pre-audit training?	
2a	Do you know about the project's system for reporting for accident/incident?	
2b	If yes, when were you told about it? (*tick one box only*)	
	• Anytime before or during induction course	
	• Only after an accident/incident had occurred	
2c	After an accident had occurred, did you receive feedback about the analysis of accident/incident investigation from management?	
2d	When did you receive the feedback of accidents/incidents investigation analyses? (*tick one box only*)	
	• Daily inspections	
	• Weekly site meetings	
	• Tool-box talks	
	• No specific time	
3a	Do you know about the project's system for reporting near misses?	
3b	If yes, when were you informed? (*tick one box only*)	
	• Anytime before or during induction course	
	• Only after an accident/incident had occurred	
3c	After a near miss had occurred, did you receive feedback about the analyses of investigation from management?	
3d	If yes, when did you receive the feedback of near miss investigation analyses? (*tick one box only*)	
	• Daily inspections	
	• Weekly site meetings	
	• Tool-box talks	
	• No specific time	
4a	Did you receive the project's safety policy from management?	
4b	If yes, when did you receive the safety policy? (*tick one box only*)	
	• Any time before or during the induction training	
	• After the induction training	
5a	Do you have planned meetings at least once a week with site management?	

No.	Indicators	Answers
5b	Are the following discussed during planned meetings with site management? *(tick each box that applies)*	
	• progress of work	
	• safety issues	
	• review of substandard performance by operatives	
	• recommendations and suggestion for any action plan to overcome this substandard performance	
5c	Did you receive any information on actions highlighted during the planned meetings with site management?	
5d	Was there any feedback on actions highlighted during the meetings through informal co-ordination?	
6a	Were you required to submit a health and safety competent record during the pre-qualification and bid evaluation?	
6b	Did you have to fill in a pre-qualification questionnaires to determine the ability to undertake the work safely based on your past experience and past performance?	
7a	Did you attend induction training on your first day on site?	
7b	Does the induction training cover the following? *(tick each box that applies)*	
	• safety rules	
	• safety policy	
	• safety regulations	
	• personnel rights and responsibilities	
	• overview of company procedures	
	• site management hierarchy	
	• introduction of personnel to their supervisors	
	• notification of emergency plan	
	• location of medical and emergency aid	
	• site layout	
	• housekeeping arrangements	
	• permit-to work systems and method statements	
	• reporting system for accidents/incidents	
	• reporting system for near misses	
	• explain security system, issue of passes and permits	
7c	Did you receive some proof of attendance after attending the induction training?	
7d	Did the induction training last for not more than one working day?	
7e	Did the site management conduct a tour of the work place noting exit dangers etc.?	

No.	Indicators	Answers
7f	Did the site management use written materials and visual aids to conduct induction training?	
7g	Did you receive proper advice regarding PPE (personal protective equipment) during induction e.g., instructions on how to wear it and how to look after it etc.?	
7h	Did you receive a safety handbook which is appropriate to you at the end of the induction training?	
7i	Was an evaluation carried out at the end of the course either verbal or written?	
8a	Did you receive copy of sub standard work from management for any remedial work?	
8b	Did the remedial work define the following? *(tick each box that applies)*	
	• Person carrying out the work	
	• Time scale to complete the remedial task	
	• Method statement to carry out the task	
9a	Do you carry out safety briefings at working areas before work commences?	
9b	Do you review risk analysis with respective workers?	
10	Are MSHDS (material safety health data sheets) provided for all personnel with specific information on chemicals that the personnel will come in contact with?	
11a	Are you informed of the necessary actions to be taken during an emergency?	
11b	Is training required for all personnel who involve to hazardous substances?	
11c	Did you participate in drills at least once throughout the project?	
12a	Do you know about the informal system for making recommendations, safety suggestions or improvements e.g. verbal or union leaders?	
12b	Do you know about the formal system where personnel are encouraged to make safety suggestions, recommendations or improvements such as: *(tick each box that applies)*	
	• suggestion box	
	• suggestion forms	
	• site canteen	
12c	Has the company ever announced any suggestions that had been accepted and who suggested them?	

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No.	Indicators	Answers
13a	Does a clear chain of command: exist among HQ management, site management, supervisors, specialist-contractors and operatives?	
13b	Do you receive work instructions during meetings e.g. daily meetings or weekly meetings	
14	On this project, have you attended any of the following training programmes? *(tick each box that applies)*	
	• Induction	
	• Pre-audit training	
	• Training for undertaking reporting of accident/incident and near misses	
	• Emergency response system	
	• Training for high risks job	
	• Training for handling hazardous materials	
	• Risk assessment training	
15a	Do you receive any medical facilities on this project e.g. first aid?	
15b	Did you complete a pre-employment medical questionnaire?	
16a	Are the goals set by management attainable?	
16b	Do the management encourage active participation of personnel in decision making?	
16c	Are you rewarded for good safety performance?	
16d	Does the existing appraisal system recognise good safety performance?	
17a	Do you work in a safe working environment?	
17b	There is a continuous message that no job is so important that safety is overlooked?	
17c	Do you know the company safety rules and procedures?	
17d	How often do you comply with the rules and procedures? *(tick only one box)*	
	• All the times	
	• Sometimes	
	• Never	
17e	How often do you follow the directions given by management or supervisors? *(tick only one box)*	
	• All the times	
	• Sometimes	
	• Never	

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No.	Indicators	Answers
17f	Regarding PPE (personal protective equipment), do you...... *(tick each box that applies)*	
	• wear because you are concerned about safety?	
	• wear it voluntarily?	
	• use only steel-toed shoes or safety boots?	
	• ensure safety shields and guards are in place and secured prior of commencement of equipment operations?	
	• use the right PPE whenever appropriate and required?	
	• Always get PPE that suits you in terms of size & height?	
	• receive training on how to use it?	
	• return used or damaged PPE and receive a reissue	
17g	Regarding tool, machinery and equipment, do you........... *(tick each box that applies)*	
	• know where safety equipment is and how to use it correctly?	
	• only handle equipment, tool and machinery when you are trained?	
	• store and maintain all equipment – ensure they are clean, safe in operation?	
	• return the equipment to the sores if condition is unsafe?	
17h	On this project, have you taken any of the following actions before? *(tick each box that applies)*	
	• reported any substandard working condition or suspected of being unsafe to the supervisor	
	• reported any near miss or incident/accident to supervisors, no matter how slight it seems?	
	• stop work if you felt it was unsafe to continue?	
18	Does the working environment provide the following? *(tick each box that applies)*	
	• proper guards and support	
	• proper illumination	
	• proper ventilation	
	• work place not congested	
	• all tools and equipment in working condition	
	• orderly work place	
	• proper warning and detection style	
	• suitable and sufficient welfare facilities	

APPENDIX 9.2 – SPMT SITE RESULTS

	Carrying out safety audit	Up-to-date safety document	Pre-tender risk assessment	System for reporting acc/inc	System for reporting near miss	Safety policy	Meeting with supervisor	Meeting with SC	Choosing competent SC	HSEComm	Full time SO	Induction training	Planned inspection	Tool-box talk	Construction risk analysis
	151	50	30	306	170	90	170	130	0	90	90	920	150	90	50
10	166	70	80	329	284	150	170	170	60	130	140	930	240	90	80
9	150	63	72	296	256	135	153	153	54	117	126	837	216	81	72
8	133	56	64	263	227	120	136	136	48	104	112	744	192	72	64
7	116	49	56	230	199	105	119	119	42	91	98	651	168	63	56
6	100	42	48	197	170	90	102	102	36	78	84	558	144	54	48
5	83	35	40	164	142	75	85	85	30	65	70	465	120	45	40
4	66	28	32	132	114	60	68	68	24	52	56	372	96	36	32
3	50	21	24	99	85	45	51	51	18	39	42	279	72	27	24
2	33	14	16	66	57	30	34	34	12	26	28	186	48	18	16
1	17	7	8	33	28	15	17	17	6	13	14	93	24	9	8
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Score	8	7	3	9	6	6	10	7	0	6	6	9	6	10	6
Weight	62	78	76	74	62	78	72	68	72	56	70	70	70	68	76
Total	496	546	228	666	372	468	720	476	0	336	420	630	420	680	456

	Method statement	Machine and tools in safe operation	Work permit	Good housekeeping	MSHDS	Emergency response system	Suggestion system	Communication	Safety promotion	Training provided	Safe behaviour exist	Safe working environment	Proper health care	Motivate personnel	Recruiting the right people
	70	20	80	130	60	100	200	100	80	190	440	180	80	130	10
10	70	20	80	130	70	100	240	120	100	320	480	240	100	160	40
9	63	18	72	117	63	90	216	108	90	288	432	216	90	144	36
8	56	16	64	104	56	80	192	96	80	256	384	192	80	128	32
7	49	14	56	91	49	70	168	84	70	224	336	168	70	112	28
6	42	12	48	78	42	60	144	72	60	192	288	144	60	96	24
5	35	10	40	65	35	50	120	60	50	160	240	120	50	80	20
4	28	8	32	52	28	40	96	48	40	128	192	96	40	64	16
3	21	6	24	39	21	30	72	36	30	96	144	72	30	48	12
2	14	4	16	26	14	20	48	24	20	64	96	48	20	32	8
1	7	2	8	13	7	10	24	12	10	32	48	24	10	16	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Score	10	10	10	10	8	10	8	8	8	5	9	7	8	8	2
Weight	94	84	78	68	64	82	64	74	58	80	86	88	74	66	68
Total	940	840	780	680	512	820	512	592	464	400	774	616	592	528	136

Performance score

STANDARD DEVIATION
2.48

SPMT INDEX
74%

90-100%	Excellent
70-89%	Very good
50-69%	Good - need to improve
30-49%	Moderate/poor - need to improve harder
0-29%	Unacceptable - need to take urgent actions

FIGURE A9.1 - SPMT INDEX FOR SITE B (test 2)

Carrying out safety audit	Up-to-date safety document	Pre-tender risk assessment	System for reporting acc/inc	System for reporting near miss	Safety policy	Meeting with supervisor	Meeting with SC	Choosing competent SC	HSEComm	Full time SO	Induction training	Planned inspection	Tool-box talk	Construction risk analysis	Method statement	Machine and tools in safe operation	Work permit	Good housekeeping	MSHDS	Emergency response system	Suggestion system	Communication	Safety promotion	Training provided	Safe behaviour exist	Safe working environment	Proper health care	Motivate personnel	Recruiting the right people	Performance score
112	60	60	215	137	125	160	160	60	0	100	621	220	75	50	70	20	80	130	55	80	47	106	70	225	410	229	60	89	40	
166	70	80	329	284	150	170	170	60	130	140	930	240	90	80	70	20	80	130	70	100	240	120	100	320	480	240	100	160	40	10
150	63	72	296	256	135	153	153	54	117	126	837	216	81	72	63	18	72	117	63	90	216	108	90	288	432	216	90	144	36	9
133	56	64	263	227	120	136	136	48	104	112	744	192	72	64	56	16	64	104	56	80	192	96	80	256	384	192	80	128	32	8
116	49	56	230	199	105	119	119	42	91	98	651	168	63	56	49	14	56	91	49	70	168	84	70	224	336	168	70	112	28	7
100	42	48	197	170	90	102	102	36	78	84	558	144	54	48	42	12	48	78	42	60	144	72	60	192	288	144	60	96	24	6
83	35	40	164	142	75	85	85	30	65	70	465	120	45	40	35	10	40	65	35	50	120	60	50	160	240	120	50	80	20	5
66	28	32	132	114	60	68	68	24	52	56	372	96	36	32	28	8	32	52	28	40	96	48	40	128	192	96	40	64	16	4
50	21	24	99	85	45	51	51	18	39	42	279	72	27	24	21	6	24	39	21	30	72	36	30	96	144	72	30	48	12	3
33	14	16	66	57	30	34	34	12	26	28	186	48	18	16	14	4	16	26	14	20	48	24	20	64	96	48	20	32	8	2
17	7	8	33	28	15	17	17	6	13	14	93	24	9	8	7	2	8	13	7	10	24	12	10	32	48	24	10	16	4	1
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	8	7	6	4	8	9	9	10	0	7	6	9	8	6	10	10	10	10	7	8	1	8	7	7	8	9	6	5	10	Score
62	78	76	74	62	78	72	68	72	56	70	70	70	68	76	94	84	78	68	64	82	64	74	58	80	86	88	74	66	68	Weight
372	624	532	444	248	624	648	612	720	0	490	420	630	544	456	940	840	780	680	448	656	64	592	406	560	688	792	444	330	680	Total

STANDARD DEVIATION
2.47

SPMT INDEX
75%

90-100%	Excellent
70-89%	Very good
50-69%	Good - need to improve
30-49%	Moderate/poor - need to improve harder
0-29%	Unacceptable - need to take urgent actions

FIGURE A9.2 - SPMT INDEX FOR SITE C

Performance score	Carrying out safety audit	Up-to-date safety document	Pre-tender risk assessment	System for reporting acc/inc	System for reporting near miss	Safety policy	Meeting with supervisor	Meeting with SC	Choosing competent SC	HSEComm	Full time SO	Induction training	Planned inspection	Tool-box talk	Construction risk analysis	Method statement	Machine and tools in safe operation	Work permit	Good housekeeping	MSHDS	Emergency response system	Suggestion system	Communication	Safety promotion	Training provided	Safe behaviour exist	Safe working environment	Proper health care	Motivate personnel	Recruiting the right people
	111	50	40	202	134	124	125	145	40	70	100	625	195	70	60	70	10	70	70	46	51	64	110	80	159	291	188	70	74	30
10	166	70	80	329	284	150	170	170	60	130	140	930	240	90	80	70	20	80	130	70	100	240	120	100	320	480	240	100	160	40
9	150	63	72	296	256	135	153	153	54	117	126	837	216	81	72	63	18	72	117	63	90	216	108	90	288	432	216	90	144	36
8	133	56	64	263	227	120	136	136	48	104	112	744	192	72	64	56	16	64	104	56	80	192	96	80	256	384	192	80	128	32
7	116	49	56	230	199	105	119	119	42	91	98	651	168	63	56	49	14	56	91	49	70	168	84	70	224	336	168	70	112	28
6	100	42	48	197	170	90	102	102	36	78	84	558	144	54	48	42	12	48	78	42	60	144	72	60	192	288	144	60	96	24
5	83	35	40	164	142	75	85	85	30	65	70	465	120	45	40	35	10	40	65	35	50	120	60	50	160	240	120	50	80	20
4	66	28	32	132	114	60	68	68	24	52	56	372	96	36	32	28	8	32	52	28	40	96	48	40	128	192	96	40	64	16
3	50	21	24	99	85	45	51	51	18	39	42	279	72	27	24	21	6	24	39	21	30	72	36	30	96	144	72	30	48	12
2	33	14	16	66	57	30	34	34	12	26	28	186	48	18	16	14	4	16	26	14	20	48	24	20	64	96	48	20	32	8
1	17	7	8	33	28	15	17	17	6	13	14	93	24	9	8	7	2	8	13	7	10	24	12	10	32	48	24	10	16	4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Score	6	7	5	6	4	8	7	8	6	5	7	6	8	7	7	10	5	8	5	6	5	2	9	8	4	6	7	7	4	7
Weight	62	78	76	74	62	78	72	68	72	56	70	70	70	68	76	94	84	78	68	64	82	64	74	58	80	86	88	74	66	68
Total	372	546	380	444	248	624	504	544	432	280	490	420	560	476	532	940	420	624	340	384	410	128	666	464	320	516	616	518	264	476

STANDARD DEVIATION
1.69

SPMT INDEX
64%

90-100%	Excellent
70-89%	Very good
50-69%	Good - need to improve
30-49%	Moderate/poor - need to improve harder
0-29%	Unacceptable - need to take urgent actions

FIGURE A9.3 - SPMT INDEX FOR SITE D

Table A9.1 – SCM performance score for Site B

Safety control measures	**Score level**	**Score results**
Toolbox talks Permit-to-work system Method statement Recruiting the right person	10	Excellent
Safety audit Safety policy Meeting with supervisors Safety officer Choosing competent specialist-contractors HSE Committee Induction training Motivation Construction risk analysis MSHDS Safe working environment Communication Safety promotion Proper health care Emergency response system	8-9	Very good
Safe behaviour Good housekeeping Procedures for reporting accidents/incidents Suggestion system	6-7	Good, but still need to improve SCMs
Procedures for reporting near misses Site inspection Training Machinery & equipment in safe working condition Meeting with specialist-contractors Safety documents	4-5	Need to work harder to improve the SCMs
Pre-tender risk assessment	0-3	Need urgent actions to improve SCMs

Table A9.2 – Respondents influence on the SMCs performance score for Site B

Safety control measures	Hq	Sm	Sup	Ops	Sc	Obs	Dc
Safety audit	94%	100%	100%	20%	75%		
Up-to-date safety documentation	0%	100%					0%
Pre-tender risk assessment	40%	0%					100%
Procedures for reporting accidents/incidents	96%	68%	50%	85%	75%		100%
Procedures for reporting near misses	29%	48%	50%	95%	75%		100%
Up-to-date safety policy	67%	100%	50%	90%	50%		100%
Safety meeting with supervisors		100%	83%				100%
Safety meeting with specialist-contractors		0%			93%		100%
Choosing competent specialist-contractors		100%			50%		
Health & Safety Committee		85%					
Safety officer	80%	100%					
Induction training		96%	87%	83%	91%	100%	
Site inspection		100%	38%		50%		0%
Tool-box talks			100%				100%
Construction risk analysis		100%	75%		100%		
Method statements		100%					100%
Permit-to-work system		100%					100%
Machinery & equipment in safe working condition.		50%					
Good housekeeping		70%				100%	
Material Safety Health Data Sheet	0%	100%	100%	60%	100%		
Emergency response system		100%		80%	100%		
Suggestions approach		88%	80%	52%	50%	100%	
Communication	100%	100%	50%	80%	75%		
Safety promotion		80%				100%	
Training	100%	100%	14%	37%	21%		100%
Safe behaviour				80%	78%	63%	
Safe working environment				83%	88%	100%	
Effective health care	100%	100%	50%	90%	75%		
Motivation personnel		100%	100%	50%	75%		
Recruiting the right people	100%	100%					

Hq Head Office Management
Sm Site office Management
Sup Site supervisors
Ops Site operatives
Obs Observations
Dc Document checks

Table A9.3 - SCM performance score for Site C

Safety control measures	Score level	Score results
Choosing competent specialist-contractors Method statement Machinery & equipment in safe working condition Permit-to-work system Good housekeeping Recruiting the right person	10	Excellent
Meeting with supervisors Meeting with specialist-contractors Site inspection Safe working environment Communication Safe behaviour Safety policy Toolbox talks Safety documents Emergency response system	8-9	Very good
Safety promotion Safety audit Safety officer MSHDS Training Pre-tender risk assessment Procedures for reporting accidents/incidents Induction training Proper health care Construction risk analysis	6-7	Good, but still need to improve SCMs
Procedures for reporting near misses Motivation	4-5	Need to work harder to improve the SCMs
HSC Suggestion system	0-3	Need urgent actions to improve SCMs

Table A9.4 – Respondents influence on the SMCs performance score for Site C

Safety control measures	Hq	Sm	Sup	Ops	Sc	Obs	Dc
Safety audit	55%	100%	50%	30%	100%		
Up-to-date safety documentation	100%	67%					100%
Pre-tender risk assessment	100%	0%					100%
Procedures for reporting accidents/incidents	95%	39%	50%	75%	75%		100%
Procedures for reporting near misses	59%	43%	50%	15%	50%		100%
Up-to-date safety policy	83%	50%	75%	100%	100%		100%
Safety meeting with supervisors		89%	100%				100%
Safety meeting with specialist-contractors		100%			86%		100%
Choosing competent specialist-contractors		100%			100%		
Health & Safety Committee		0%					
Safety officer	80%	67%					
Induction training		87%	87%	7%	85%	100%	
Site inspection		100%	100%		50%		100%
Tool-box talks			200%				100%
Construction risk analysis		50%	63%		75%		
Method statements		100%					100%
Permit-to-work system		100%					100%
Machinery & equipment in safe working condition.		100%					
Good housekeeping		100%				100%	
Material Safety Health Data Sheet	0%	100%	50%	100%	100%		
Emergency response system		100%		67%	67%		
Suggestions approach		25%	20%	24%	10%	0%	
Communication	100%	100%	50%	80%	100%		
Safety promotion		60%				80%	
Training	100%	100%	50%	43%	71%		100%
Safe behaviour				83%	83%	100%	
Safe working environment				93%	94%	100%	
Effective health care	100%	67%	50%	25%	25%		
Motivation personnel		75%	38%	60%	50%		
Recruiting the right people	100%	100%					

Hq Head Office Management

Sm Site office Management

Sup Site supervisors

Ops Site operatives

Obs Observations

Dc Document checks

Table A9.5 - SCMs performance for Site D

Safety control measures	**Score level**	**Score results**
Method statement	10	Excellent
Communication Site inspection Permit-to-work system Safety promotion Safety policy Meeting with specialist-contractors	8-9	Very good
Meeting with supervisors Safety audit Safe working environment Choosing competent specialist-contractors Safety officer Toolbox talks Construction risk analysis MSHDS Safe behaviour Proper health care Recruiting the right person Safety documents Induction training Procedures for reporting accidents/incidents	6-7	Good, but still need to improve SCMs
HSE Committee Good housekeeping Training Pre-tender risk assessment Procedures for reporting near misses Machinery & equipment in safe working condition Emergency response system Motivation	4-5	Need to work harder to improve the SCMs
Suggestion system	0-3	Need urgent actions to improve SCMs

Table A9.7 - SCMs performance for Site A - test 2

Safety control measures	Score level	Score results
Communication Safety documents Pre-tender risk assessment Permit-to-work system Machinery & equipment in safe working condition Recruiting the right person Motivation	10	Excellent
Safety policy Meeting with specialist-contractors Method statement Meeting with supervisors Choosing competent specialist-contractors Safety officer Construction risk analysis Safe behaviour Good housekeeping Induction training	8-9	Very good
Safe working environment Toolbox talks Proper health care Procedures for reporting accidents/incidents	6-7	Good, but still need to improve SCMs
Safety audit MSHDS Training Site inspection Procedures for reporting near misses Safety promotion Emergency response system	4-5	Need to work harder to improve the SCMs
Suggestion system HSE Committee	0-3	Need urgent actions to improve SCMs

Table A9.8 - SCMs performance for Site B - testing 2

Safety control measures	**Score level**	**Score results**
Communication Machinery & equipment in safe working condition Recruiting the right person Safety officer Method statement Permit-to-work system Safety promotion Emergency response system	10	Excellent
Meeting with supervisors Proper health care Safe behaviour Induction training	8-9	Very good
Safe working environment Toolbox talks Safety audit Procedures for reporting accidents/incidents Motivation Meeting with specialist-contractors Choosing competent specialist-contractors Pre-tender risk assessment Safety documents Construction risk analysis Good housekeeping MSHDS Suggestion system HSE Committee	6-7	Good, but still need to improve SCMs
Training Site inspection Procedures for reporting near misses Safety policy	4-5	Need to work harder to improve the SCMs

APPENDIX 9.3– COMMENTS FROM SITES ABOUT SPMT

MOWLEM

Mowlem Midlands
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REP/BED/SAFETY

30 May 2000

Miss Radhlinah Kunju Ahmad
Department of Civil and Building Engineering
Loughborough University
Loughborough
LE11 3TU

Dear Linah

Re: Safety Performance Measurement Tool (SPMT)

I am very pleased to have been able to help you test SPMT in a live situation.

It is ironical that my Company has been looking at a similar approach, though not as sophisticated, to monitor the effectiveness of communication from director to site operative.

The principle of SPMT is sound and in theory one should be able to identify very quickly the point where communication begins to falter. However, there are two significant obstacles:

1. Quite a few of the questions were unsuitable / ambiguous. This was inevitable as there had been no contact between the two of us prior to the field trials. In practice such anomalies would be resolved by closer liaison and tailoring the questions to suit the peculiarities of each company.

2. My second concern relates to the people who will be interviewed. Any formal interview will be treated with caution and may not produce honest answers. Construction site manual workers are most suspicious when questioned about their work or their relationship with site management. They may answer in a mischievous way (because they want to get back at someone) or, at the other extreme, they will tell you what they think you would like to hear (because they think it will be to their advantage to secure future work, say).

Cont'd/....

Either way, the processing of the questionnaires is effective in highlighting areas for attention and improvement. Ideally the trail of questions on each topic should cover every level of employee. For example, a policy decision made by a director on, say, near miss reporting should be known by managers, supervisors, sub-contractors and workmen alike. Obviously not everyone would be expected to know the policy verbatim, but everyone should know the gist of what is required or know whom to ask. Therefore a low score on the Respondents chart would readily signal a problem.

I do not consider it appropriate for the questionnaire to be simply issued for completion as too many explanations will arise. Interviews also open up discussion and many matters can usefully be dealt with, which otherwise may not be raised in another forum. Certainly your proposal to use the questionnaire in an electronic form is too ambitious at the present time.

In conclusion, I believe that SPMT has great potential and with further development in terms of being tailored more to the needs of individual companies, will provide a good audit tool for improving not only safety but also other facets of management. It is a pity that more time is not available in order to progress the study further.

Good luck for the future.

Yours sincerely

Roy

Roy Perkins
REGIONAL SAFETY MANAGER

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22nd May 2000

Ref: AR/CB/jvs

Miss Radhlinah Kunju Ahmad
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Loughborough
LE11 3TU

Dear Linah,

VAM/ETAC ALLIANCE PROJECT
BP-AMOCO CHEMICALS LIMITED – HULL

Subject : Safety Performance Measurement

Many thanks for the time and effort you have put into helping us use the Safety Performance Measurement tool on the project. It has helped us identify our strengths and, more importantly, our weaknesses.

Following receipt of the results of our last measurement, we have put some actions in place to help correct our identified failings.

We will, in the very near future, re-measure our performance using SPMT, and if we may, would again ask you to help us interpret the results and offer advice.

Once again, many thanks for your help.

Yours sincerely,

Chris Booker

CHRIS BOOKER
Safety Co-ordinator
VAM/ETAC Alliance Project

Cc: AR
CB
Doc Control