**University Of Western Sydney**

In Conjunction with

**The Hong Kong Polytechnic University**

# Research into Safety Audit In Construction Industry in Hong Kong

by

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A report submitted as partial fulfillment of the requirements for Master of Applied Science (Safety Management)

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| ACSNI | Advisory Committee on the Safety of Nuclear Installations |
| CAC | Codex Alimenarius Commission |
| CCPI | Critical Control Point Indicator |
| CPI | Control Point Indicator |
| CHASE | Complete Health and Safety Evaluation |
| HACCP | Hazard Analysis and Critical Control Point |
| $H_0$ | Null hypothesis statement |
| $H_0 1$ | Null hypothesis statement for phase one study |
| $H_0 2$ | Null hypothesis statement for phase two study |
| $H_0 3$ | Null hypothesis statement for phase three study |
| $H_1$ | Alterative hypothesis statement |
| HKSAR | Hong Kong Special Administrative Region |
| ISAS | Independent Safety Audit Scheme |
| JHA | Job Hazard Analysis |
| NASA | National Aeronautics and Space Administration |

| | |
|---|---|
| OHS | Occupational Health and Safety |
| $O_1$ | Objective 1 |
| $O_2$ | Objective 2 |
| $O_3$ | Objective 3 |
| PASS | Performance Auditing Scoring System |
| PI | Performance Indicator |
| PPI | Positive Performance Indicator |
| SE | Safety element |
| SME | Small to medium enterprise |
| SMS | Safety Management System |
| SO | Safety Officer |
| SP | Safety Policy |
| SPSS | Statistic Package for Social Science |
| SSEA | Stamped self-addressed envelop |

# Abstract

Audit is the final review for a performance cycle. Various safety audit tools are available in Hong Kong. Of which 'Independent Safety Audit Scheme' (ISAS) may be dominant in Hong Kong due to its relevancy to the mandatory safety auditing requirement for construction industry. However the averaging effect of safety elements of the ISAS giving overall performance is found unpresentable at 12 construction sites over one-year ISAS auditing period from October 1998 to July 2000. For improvement on assessing the performance, Hazard Analysis and Critical Control Point (HACCP) Process has classified 14 safety elements of the ISAS into two-tier performance indicators namely control point indicator (CPI) and critical control point indicator (CCPI). In a bid to check the feasibility of HACCP integrating into ISAS, the effort and attitude held by top management affecting the implementation of safety management system (SMS) have been factor analyzed. Results indicate that the CPIs can clearly assess the effectiveness of implementation of SMS whereas CCPI could precisely unveil the progress of the continuous improvement of SMS.

# CHAPTER 1 INTRODUCTION

This project is to study the safety audit system---Independent Safety Audit Scheme (ISAS) treated as the final review of the performance cycle in construction industry in Hong Kong. The project attempts to evaluate whether or not the ISAS can measure and reflect truly the safety performance of the organizational safety management system. Information collected in the study may be utilized for the design of an appropriate evaluation yardstick---safety audit system for the construction industry. By virtue of it, the employer and parties concerned may know how to correctly judge or improve their health and safety performance.

In 1992 the last governor Mr. Chris Patten made his comment on industrial safety that the record particularly in the construction industry was deplorable (Lam & Rowlinson 1997, p. 22-25). Many public sectors related to building industry have struck safety management checking systems as solutions to Patten's accusation. Solutions include the Works Branch with its Pay-for-Safety Scheme; the Construction Association with its Green Card System; Housing Department with its Performance Auditing Scoring System (PASS); and the Building Department with its Site Monitoring System.

One typical solution to combat the high accident rate in construction industry is figured out by the Works Branch of the HKSAR Government. It in co-operation with the HK Construction Association, initiated and tested an 'Independent Safety Audit Scheme' (ISAS) through a series of pilot projects in 1994. The ISAS is to test the safety system of the building contractors. Finally it becomes a pre-requisite requirement for bidding all housing department jobs as well as the Works Branch's construction projects by building contractors.

## MAGNITUDE OF THE PROBLEM

However over the past 5 years from 1993 to 1997, the construction accidents had still ranked top in selected industries namely catering, transport, storage and communication and manufacturing (Labour Department, 1999). The annual accident rate was surged up to the record high as 18,559 in 1997. Furthermore, the construction industry occupied only 11 per cent of workforce but contributed 39 per cent of industrial accidents in 1999 (Mak & Chan, 2000).

Various safety control measures instigated by the public sectors were criticized as all fragmented without any party to coordinate their initiatives aiming at building the in-house safety factor into their daily work (Tam, 1996). Doubt may be cast on the effectiveness of safety effort made by various government departments even thought have they paid a lot of effort on health and safety issues for construction industry.

## REGULATORY CONTROL

The Robens Report signalled a move away from detailed prescriptive regulations towards the broader obligations of the Health & Safety at Work etc. Act 1974 and also the concept of self-regulation (Deacon, 1994). The emerging self-regulation was used as "…not just self-enforcement of the rules and regulations made by outsiders, but involves the purposeful creation and maintenance of specific tailor-made standards and controls commensurate with the risks inherent in their undertakings" (Deacon, 1994). The self-regulation approach advocated in the UK's Robens Report has become a blue print for Hong Kong counterparts when developing the safety management systems as well as the health and safety legislation (Cheung, 1996).

In this aspect, the enactment of the general duty provision in Hong Kong aiming at self-regulation is to encourage the integration of safety and health into their day-to-day management activities. The effectiveness of the organization's safety and health management systems is therefore statutorily assessed. (Pang, 1995).

## SUSPECTED PROBLEMS WITH SELF-REGULATORY CONTROL

The self-regulation seems to be elusive. It may be due to the fact that the self-regulation at workplace can be effective, but only if adequately allocated with resources. Furthermore, in industry self-regulation is obviously not a common practice management principle. The under-performance was complex, but failure of management to prevent avoidable accidents was seen as a prime cause by the UK Health and Safety Executive (Deacon, 1994). For example, poor inspection or failure of supervision may have no immediate effect and remains latent until some further factors push the situation over the edge. Therefore a good health and safety management system pays a significant role to combat high accident rate in the construction industry.

## SAFETY MANAGEMENT SYSTEM

The Safety Management System (SMS) is an instrument attempting to capture the management factor in safety and to focus attention on underlying control failures at various sub-system levels (Cameron, 1997). It has been argued that one of the strongest barriers to effective managerial involvement in safety is a reluctance to accept safety as an important performance criterion (Leather, 1988). Their success may be essentially practical like doing what is necessary and absolutely nothing more. A practical research has revealed that small to medium enterprise (SME) managers are very reluctant to adopt the idea of implementing an occupational health and safety management system in comparison to their enthusiasm to proceed with the implementation of a quality assurance system ISO 9000 series (Charalambous, 1998). Therefore the drive for their commitment to safety may be due to the veiled threats of prosecution (Marriott 1997).

**SAFETY AUDIT**

The audit as the final step in a health and safety management control cycle to review performance can help an organization to achieve success in health and safety (HSE, 1991). Dr. Alex Cheung, the president of Hong Kong Occupational Safety and Health Association emphasized that the safety audit was a measurement tool to evaluate the safety performance of an organization and to identify areas which demanded improvement (Cheung, 1996). The safety audit provides the means for identifying control weaknesses that gives rise to unacceptable levels of residual risk and recommending means of improvement to shift the risks to acceptable levels (Robinson, 1997). It enables a deeper and more critical appraisal of all the elements of the OHS management system (British Standard Institute, 1996).

A range of good safety audit systems, such as Construction Complete Health and Safety Evaluation (CHASE), International Safety Rating System, and 5-star Health and Safety Management System are available in Hong Kong. Many employers have adopted and used these systems to measure their safety performance and to check regularly all controls systems which may tend to deteriorate over time or to become obsolete as a result of change (Cheung, 1996; HSE, 1991).

Dr. K.F. Lee, the then Deputy Commissioner for Labour addressed the seminar on the Occupational Safety Charter on 4th March 1997 that a mandatory Safety Management

System shall be implemented and adopted by the construction company (Hong Kong Institute of Engineers, 1997). Since November 1999, the Government has introduced a safety management regulation to require proprietors, who employ more than 100 workers in certain high-risk industries including construction sites to implement a safety management system (Mak & Chan, 2000). In addition such employers need to employ a registered safety auditor to conduct regular safety audits for ensuring an effective implementation of the safety management system. It aims at assessing the effort paid by the building contractors (Lai, Tang & Poon, 1996). However this time the requirement of safety auditing is no longer confined to government contract but extends to private construction contract.

Coincidentally, the mandatory safety management with 14 safety elements proposed by the Deputy Commissioner for Labour is same as those advocated in the ISAS. There is no doubt that the ISAS may be used to monitor the safety management system in the construction industry due to its relevancy to the mandatory safety auditing requirement for the construction industry.

**EFFECTIVENSS OF ISAS**

It is expected that the ISAS will navigate the course heading to the health and safety audit with continuous improvement of the organizational safety management system. ISAS may also form a panacea as one of assessment tools for self-regulatory compliance from the eyes of the enforcement body. The ISAS consisting of 14 safety elements (SEs) constitutes of the main core of assessment tools for the proprietary SMS adopted by building organization.

The success of implementing and improving the SMS is revealed by the achievement on the average score of overall performance for these 14 SEs. The organizational attention may only target at getting a pass score of 70 per cent as stipulated in ISAS. Therefore the assessment tools of ISAS will be crucial to comment on the safety performance of an organization. In this regard, problems may arise when the safety audit cannot identify the inadequacy in the scoring system; or gives a wrong indication of a pass score; or when some companies might seek to improve their audit score in ways that do not, in fact, lead to real improvements in safety (Booth, 1996). This may explain the ever-increasing accident rate in Hong Kong as an outcome of poor safety performance.

Then what kind of a scoring system of the safety audit has really told or should have told. Perhaps it provides no assurance that the organization is truly permeated by the underlying attitudes, beliefs, and mutual trust that make up a good safety culture. It seems that the applicability of the audit system in the safety management system in the Hong Kong construction industry still has some room for improvement.

Audit systems have been criticized for using superficial questions, which fail to evaluate underlying issues (HSE, 1993). They fail to adequately measure managerial day-to-day safety effort and therefore can be plagued by the problem of constancy of scores (Cameron, 1997). In addition if the shortcomings identified by audits are not taken seriously, the audit is inevitably ineffective (Pybus, 1996). It is the very essence of the work ethic in Hong Kong to carry out tasks only to such an extent that they reach the minimum acceptable standard---that attitude can be found at all levels from the worker through supervision to the most senior management (Robson, 1999).

Therefore a scoring system of the ISAS safety audit, if it truly reflects the safety performance, may help all law enforcers, developers, contractors as well as the worker to safeguard their health and safety and properties.

In essence there is a pressing need to figure out whether or not the scoring system in a safety audit is a good performance indicator in assessing the safety performance of an organization and at the workplace. This, therefore, is the main theme of the study.

# CHAPTER 2    LITERATURE REVIEW

Safety Audit is a method to measure the safety performance of a safety management system (Grimaldi & Simonds, 1989). There are different types or levels of audit, such as a strategic audit on policy and strategy; an operational audit on local procedures; as well as a system audit on standard setting (Pybus, 1996).  As for a well-defined auditing system, there must be a standpoint from which to judge performance (Granville, 1996).

The level of compliance in the safety audit is considered as an indicator of operating effectiveness, because the audit is not simply concerned with whether regulations are followed.  Overall performance in controlling operations' safety is the audit's quest, rather than simply determining what safety oversights exist (Grimaldi & Simonds, 1989).  Therefore setting some performance indicators in a safety audit poses a very crucial role to say whether or not the performance of a safety management system is appropriate so as to review and correct the inadequacy.

## PERFORMANCE INDICATORS

Performance indicators as agreed by the National Federation of Housing Association, the United Kingdom, are facts which help the assessor to assess whether or not the targets are achieved and thereby the objectives (National Federation of Housing Association, 1992).  Performance Indicators (PIs) help judge how well a service is being delivered; how well it is meeting the needs it is supposed to meet.

PIs are normally percentages or ratios that relate measured performance to a base line objective (National Federation of Housing Association, 1992).  For example, the PI may measure the direct result such as accident rate, or it may lead to knowing or predicting the performance such as an extent of fulfillment of a preset target.

## EFFECTIVENESS OF PERFORMANCE INDICATORS

Indicators must provide regular information on safety performance to enable continuous improvement relative to the organization's goals (Costigan & Gardner, 2000). It is in line with the advocacy in the BS8800 1996: Guide to Occupational Health and Safety Management Systems that the audit is used as a final step to assure continuous improvement in the safety management.

## CLASSIFICATION OF PERFORMANCE INDICATORS

### Systemic and organic measure of performance indicator

Performance measures can be divided into two classes namely systemic measures and organic measure (Grimaldi & Simonds 1989). The systemic measure or general measure is concerned with the effects of a safety programme or achievement of the aims, such as a reduction of fatalities and severe injuries. Whereas the organic measure attempts to evaluate how well the safety programme is designed and fulfilled such as safety inspection, safety committee and compliance to regulation.

### Positive performance indicators (PPIs)

Costigan and Gardner (2000) agree that positive performance indicators can show how good the performance is prior to the happening of any accident or unwanted outcome. For instance, risk assessment and process control to strengthen the operational effectiveness can be treated as PPI to prevent accidents time over time.

**Predicator of safety performance**

Safety culture may be defined as all forms of learned behaviour which add up to a shared commitment to think safely, to behave safely and to trust in the safety measures put in place by the organization (Coote & Lee, 1993). Top-down driven safety culture involving attitudes, values and beliefs may be a key predictor of safety performance (Beck & Woolfson, 1999; Harvey, Bolam and Gregory, 1999; Marsh, 1999).

**Input and output performance indicators**

Input performance indicators are practical factors which can improve the safety performance through controllable and manageable positive actions and measures (Pybus, 1996). Output performance is an outcome of performance of a management system (Kirkwood, 1997). For example, operational procedures lay down what should happen; risk assessments identify what might happen; and accident investigations reveal what actually happened. The input performance indicators are therefore an effort to prevent accidents from happening such as process control programme and risk assessments, whereas the output performance indicators provides information about the consequence of the safety management system such as accident and incident investigation.

**Lead and direct performance indicators**

A study conducted by Olson et al (1988) identified two types of safety performance indicators, namely lead indicator and direct indicator. The lead indicator measures the achievement of preset objectives which are not directly related to the safety outcome. In contrast, the direct performance indicator measures the safety outcome such as the accident rate.

## COMMENT ON PERFORMANCE INDICATORS

It is believed that the management may adapt their behaviour selectively to score well in areas that are known to be performance indicators used by the regulatory body. That is why people commonly use the 14 safety elements in ISAS safety audit as their performance indicators since the government passed the mandatory safety audit with 14 safety elements under Factories and Industrial Undertakings (Safety Management) Regulation in 2000. In this connection, Safety Management System (SMS) audit scores represent a key indicator of managerial effectiveness (Cameron, 1997).

These 14 safety elements are safety policy, safety organization, safety training, safety in-house rules and regulations, safety promotion, personal protection programme, job hazard analysis, health assurance programme, programme for inspection of a hazardous condition, process control programme, safety committee, accident and incident investigation, emergency preparedness and evaluation, selection and control of sub-contractors. As mentioned, some of these safety elements are lead, positive and input performance indicators or predicators; whilst others are outcome, output and direct performance indicators.

Out of these 14 safety elements, the accident rate as an output or direct performance indicator is regarded as an insufficient or misleading statistic in measuring safety performance as revealed by (HSE, 1991 & 19993; Lai, 1995; Tam, 1996). There is also a recurring criticism on the failure of outcome indicators which cannot provide meaningful information to improve organizational OHS performance (Amis & Booth, 1992; Glendon & Booth, 1995; Hopkins, 1994; Petersen, 1989; Shaw & Blewett, 1994 & 1995; Sweeney, 1994; Whiting, 1995). On the other hand, lead indicators may give early warning of trouble. Thus, Pybus (1996) stated that improving the performance on both inputs and processes can lead to an improvement of the output performance. Furthermore, in the study of Olson et al (1988), the authors were unsuccessful in attempting to correlate direct indicators with lead indicators. Therefore the average score of a whole basket of 14 safety elements characterized as either lead or output performance indicators may not guarantee a continuous improvement on health and safety performance for a safety management system.

## IDEOLOGY OF PERFORMANCE INDICATORS

The real difficulty of selecting or developing performance measures lies indeed not in determining what objectives are required, but in deciding how to set them (Drucker, 1954). It is believed that two-tier performance indicators should be established for the ISAS safety audit. First level indicators measure the successful implementation of the safety management, and second level indicators should give early warning of trouble (HSE, 1993).

The way of developing 2-teir performance indicators for ISAS safety audit appears to be supported by the study conducted by Dr. Mayhew in 1999. She reports that some hazards and risks in a particular industry should be identified through a series of on-site audits, whereas subsequent future visits should be tightly focused on particular problem areas (Mayhew, 1999). The focusing audit has been satisfactorily adopted by the US Occupational Safety and Health (OHS) since October 1994 (Smith, 1995).

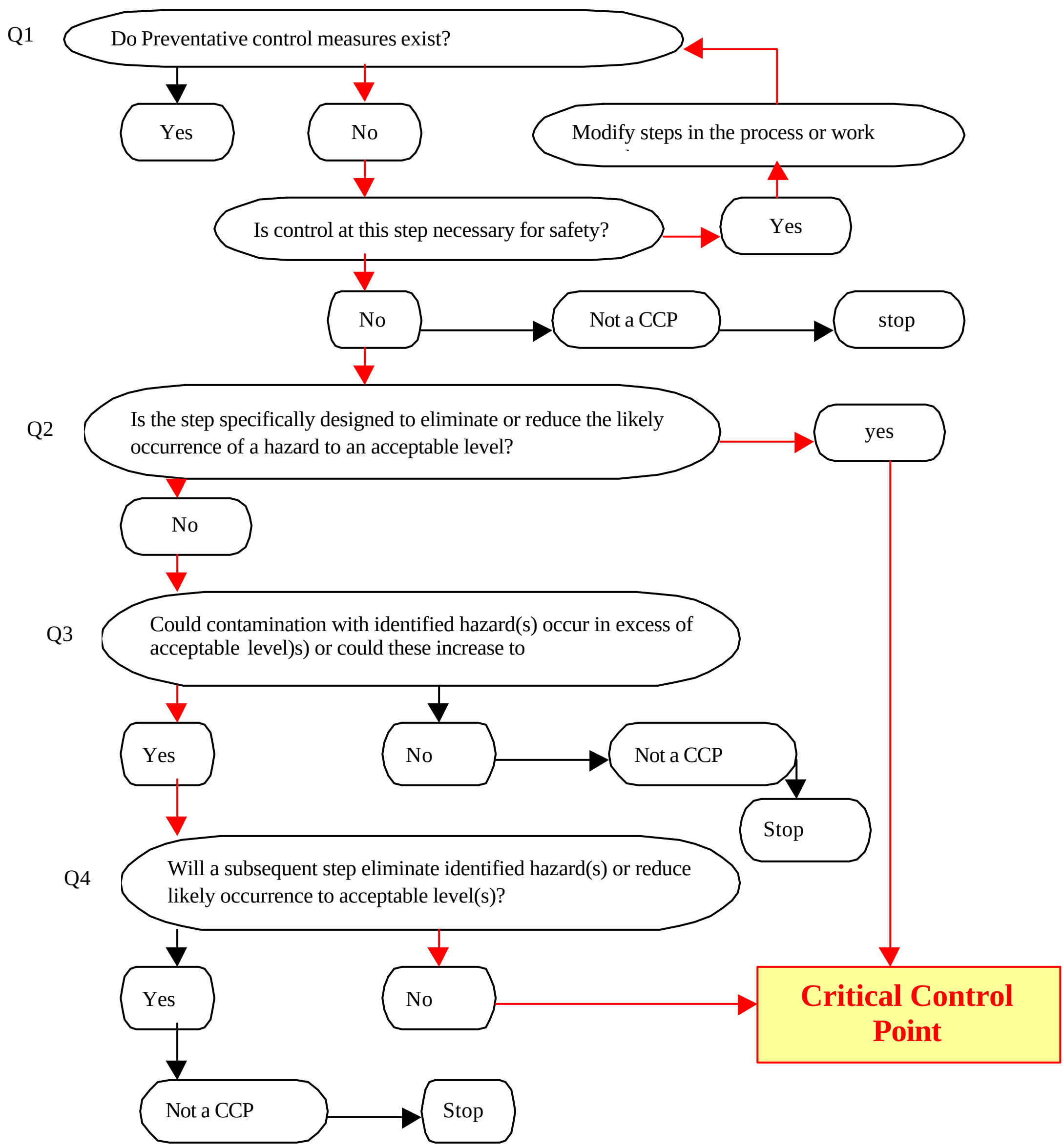
## IMPROVING ISAS BY THE APPLICATION OF HAZARD ANALYSIS AND CRITICAL CONTROL POINT (HACCP) MODEL

The original concept of HACCP aimed at producing a nil-defect programme of food production for astronauts by joint effort of the Pillsbury Company, National Aeronautics and Space Administration (NASA) and the US Army, Natick Laboratories in 1973. HACCP relies on a science and systematic approach to identify specific hazards and measures control to ensure the safety of food. The further development of HACCP leads to a conclusion that it is a tool to assess hazards and to establish control systems focusing on prevention rather than relying mainly on end-product testing (CAC, 1997).

To extrapolate the process of HACCP, the safety elements also the components of ISAS safety audit are then gone through the HACCP decision tree as shown in figure 1. Each safety element of ISAS is analyzed for its potential contribution to safety. In essence, two groups of safety elements could be identified. One is the control point indicator (CPI) and the other is the critical control point indicator (CCPI).

The CPIs are to measure the effective implementation of a safety management system. The CCPIs are to measure the particular problem areas of the system so as to focus the managerial attention to high-risk areas. One of the merits of this HACCP model is that no matter what control process is in the workplace, two-tier safety performance indicators namely CPI and CCPI could still be figured out through the HACCP decision tree to assess the performance of SMS.

**Figure 1 HACCP decision tree**




(CAC, 1997)

## APPLICABILITY OF HACCP INTO ISAS

The study carried out by Charalambous (1998) concludes that the structure approach helps managers to introduce a successful and proactive health and safety management system. This system helps managers to assess the existing health and safety performance of the company; and to identify the areas required top priority action. It appears that the HACCP can effectively apply into ISAS as it also carries similar characteristics of structure approach developed by Charalambous.

Furthermore, studies reveal that the successful implementation of an occupational health and safety management system and the success of safety auditing depend on gaining the top management commitment at an early stage (Charalambous, 1998; Granville, 1996). It may be because the organization formally or informally shapes attitude clusters and behavioural patterns (Cameron, 1997). Therefore to ensure successful implementation of HACCP into ISAS for assessment of the safety performance, the top management commitment should be looked at as well.

As a top management commitment may often give valuable information in assessing the workability of HACCP into ISAS, both safety effort and attitude of the top management should be studied. This proposition is supported by some studies. Lai, Tang and Poon in 1996 indicated that there was a correlation relationship of predicting safety performance and the safety management efforts of contractors. In the study carried out by Lai (1995), the author noted that it is worthwhile to study the attitude of Hong Kong contractors towards safety management and how safety is managed in their companies so as to improve safety performance. In all it is necessary to study the safety effort and attitude of the top management aiming at successfully applying HACCP into the ISAS.

## CONCLUSION TO LITERATURE REVIEW

A good audit relis on a standpoint from which to judge performance of the safety management system. The current mandatory safety audit system uses 14 safety elements identical to those in ISAS including both predicators and outcome indicators. Its evaluation is based on the final average score of all these 14 safety elements so as to review and correct the inadequacy. It is noticed that some safety elements are predicators which can predict the unwanted outcome so as to prevent it from occurrence. However some of them are output indicators that can only give information on what extent the target has been met. These types of indicators are somehow shown two phases of performance as advocated in the study of ACSNI study group. In essence, the parties concerned including statutory bodies as well as the management themselves cannot rely on this audit to assure an continuous improvement in the safety management.

It is suggested that HACCP can be applied into the ISAS giving two-tier performance indicators. First the control point indicator (CPI) tells how successful implementation of the safety management is. Second the critical control point indicator (CCPI) tells the early warning of trouble that focusing on particular problems for prevention.

To ensure effective application of HACCP into the ISAS, both safety attitude and effort paid by the top management are looked at. It is because the top management may shape the organization with resources to meet what the enforcement body sees. Therefore it is justified to carry out some studies on the correlation between safety attitude and safety effort of the top management and the safety audit-ISAS when devising some basic and critical control performance indicators for the safety audit.

**AIM**

To evaluate the effectiveness of the safety audit as a final step to review performance in the health and safety management cycle in construction industry.

**OBJECTIVES**

This study attempts:

- To study how top management of the building contractors discharge their mandatory safety audit duty for their safety management system;
- To assess the extent of problems when top management uses ISAS as performance indicators to evaluate their safety performance;
- To develop a safety performance critical control point model for identification of essential elements for safety audit.

**EXPECTED OUTCOME OF THE STUDY**

The current ISAS uses 14 safety elements at equal standpoint to judge the overall performance of safety management system referring to an average score for a passing grade. Of which the averaging effect of 14 safety elements lead to hide problem areas. The proposed HACCP model could identify two-tier performance that measures an effective implementation of safety management on one hand, and identifies some safety elements to assure continuous improvement at particular problem areas on the other. The expected outcome of the study is demonstrated at figure 2 to improve ISAS by switching to ISAS with HACCP.

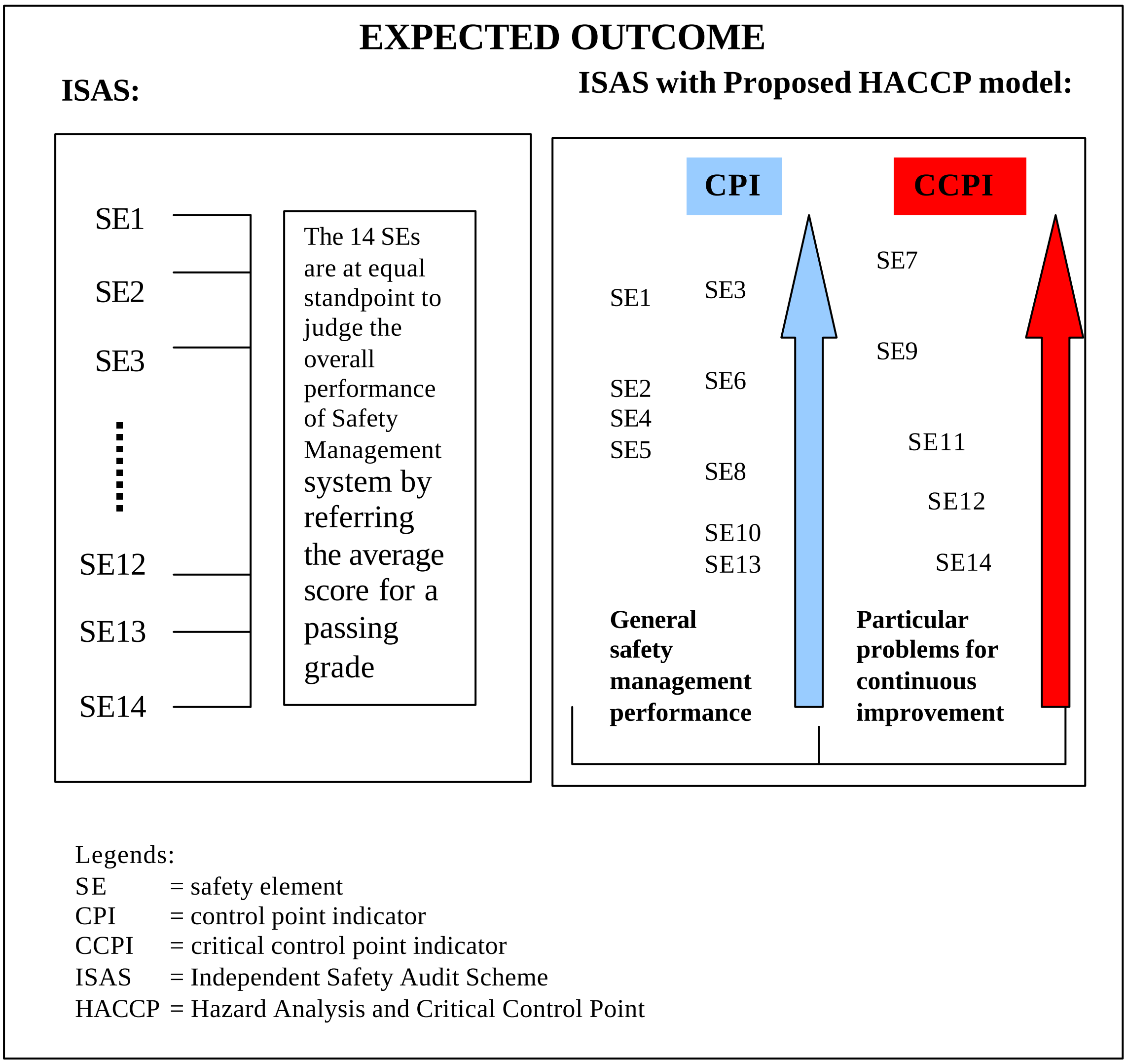



Figure 2 Expected Learning Outcome (designed by the author)

# CHAPTER 3 WORKING DEFINITIONS

## BACKGROUND VARIABLES

The ‘Independent Safety Audit Scheme (ISAS) consists of 14 safety elements which are defined under Auditor’s self-verification guide of version 1.1 produced by Occupational Safety and Health Council (OSHC, undated). These elements are briefly described as follows:

**Safety policy** indicates the declaration of intent by the top management, communication and implementation of policy and revision of the policy. It can treat as a documentary proof that there is a written safety policy applied to the organization.

**Safety organization** mentions the organizational structure showing the setup of health and safety section. It is directly under the top management so as to ensure its independence.

**Safety training** reveals the knowledge of health and safety competence held by employees as well as employer. The form of training may be in-house informal training, toolbox talk or formal external training.

**In-house safety rules and regulations** mainly deal with the organization rules as well as the legal requirement. This is a measure of identification of all suitable local or legal requirements related to health and safety.

**Safety committee** is a purposely-set committee chiefly tabling health and safety matters. It forms one of the most important bases for communication with the top management.

**Programme for inspection of hazardous conditions** provides physical workplace inspection evidence as a means of supervision and monitoring programme. It emphasizes what is oversight and what follow-up action should be taken.

**Job hazard analysis** are process controls providing very useful information as risk assessment on how to devise the corresponding safety procedures, method statements or specialized permits to work system.

**Personal protection programme** is the physical evidence of what personal protective equipment has been provided for the workers at work. There is also a requirement to show that instruction, supervision, training and information are given for the workers on how, what and why to wear the personal protective equipment.

**Accident/incident investigation** is a documentary proof element to ensure an investigation procedure is in place following an accident or incident.

**Emergency preparedness** is a plan purposely built for any unexpected disaster which may happen. It could minimize damages if the emergency plan is properly designed and considered.

**Safety promotion** is a kind of organizational self-initiative activities aiming at promoting the safety and health culture in the workforce.

**Health assurance programme** is to assess substances hazardous to health, and then to develop control measures for maintaining the welfare of employees.

**Evaluation, selection and control of subcontractor** are procedures on giving information on how to choose the sub-contractor in relation to health and safety. The evaluation, selection and control of the subcontractor adds more concern on health and safety matters.

**Process control programme** is divided into two types of work namely, management of the place of work I. It includes fire arrangements, work in confined spaces, working at height, housing keeping and protection against falling objects. The other type is Management of the place of work II (for utilities work) which includes work over or adjacent to water and overhead and underground services. The second type is concerned about the utility work that is not considered in the field of construction works.

## INTERVENING VARIABLES

### Time of the study

The time period for study consists of two parts namely retrospective data collection through the past one-year period from end of 1998 to early 2000 and real time data analysis through questionnaire-survey from mid-July to early-August 2000.

**Types of construction work**

The types of construction work under study belong to the housing construction contracts offered by the Hong Kong Housing Department. There is a contractual requirement to run the ISAS to supervise and monitor the safety and health issues at workplace.

**Size of the construction works**

In order to ensure the study samples are as similar as possible, the contract size of the construction work is defined by the contract sum which is dominant in the current market under Housing Department's building tender.

## DEPENDENT VARIABLES

The score used in the safety audit to indicate the safety performance of the proprietary safety management system for the building organization.

## INDEPENDENT VARIABLES

The safety performance indicators of 14 safety elements forming the assessment tool of the ISAS to check whether or not they can truly reflect the safety performance of the organization employing their proprietary safety management system.

## WORKING PRINCIPLES OF HACCP

By referring to the HACCP decision tree at the flow chart as shown in figure 1, the safety element has to answer the question step by step until a final outcome for the classification of whether it belongs to CPI or CCPI. During questioning, the technical terms used in the preset question are defined for clear interpretation as follows:

**Control** : to take all necessary actions to ensure and maintain compliance with criteria established in the HACCP plan. In this study, the 14 safety elements have been defined with their working principles.

**Control measure**: any action and activity that can be used to prevent or eliminate a safety hazard or reduce it to an acceptable level.

**Corrective action**: any action to be taken when the results of monitoring at the CCP indicate a loss of control.

**Critical Control Point (CCP):** a step at which control can be applied and is essential to prevent or eliminate a safety hazard or reduce it to an acceptable level.

**Critical Limit**: a criterion which separates acceptability from unacceptability. It may be either prescriptive if there is a legal standard or self-regulatory if no such standard is legally set. Then the effectiveness of the critical limit heavily relies on the professionalism of the operator.

**Deviation**: failure to meet a critical limit.

**HACCP**: a system identifies, evaluates, and controls hazards which are significant for safety.

**Hazard**: in a form of either a biological, or chemical or physical agent at workplace potentially causes an adverse health or safety effect.

# CHAPTER 4 STATEMENT OF RESEARCH HYPOTHESIS

**Operational/experimental Hypothesis**

Safety auditing system of ISAS plays a significant role as a performance indicator to show whether or not the prescribed organization's standards are met and to provide useful information for continuous improvement.

**Alternative Hypothesis, $H_1$**

**$H_1$**: The operational hypothesis predicts that the scoring system used in the safety auditing, ISAS is not a good performance indicator of safety management system in building organization with government contracts in Hong Kong.

**Null Hypothesis, $H_0$**

The null hypothesis **$H_0$** predicts:

**$H_0$1**: There is no significant correlation when comparing the score of 14 individual safety elements of the ISAS that can provide consistent and useful information to ensure continuous improvement in the safety management system.

**$H_0$2**: There is no significant correlation among the attitude and effort held by the top management of building contractor and the 14 safety elements of ISAS when discharging their corresponding mandatory safety and health duties.

**$H_0$3** There is no significant correlation if the 14 safety elements are grouped into another type of performance indicators under an assessment tool HACCP.

# CHAPTER 5 RESEARCH DESIGN AND METHODS

## RESEARCH DESIGN

The research design is in three stages. Each stage of research is targeted at an expected outcome. The expected outcome aims at defining problem areas in ISAS for assessing effective implementation of safety management system, looking for potential solution and evaluating the applicability of the improvement measures. Finally it is hoped that the aim of the study "to evaluate the effectiveness of the safety audit as a final step to review performance in health and safety management cycle in construction industry in Hong Kong" can be achieved.

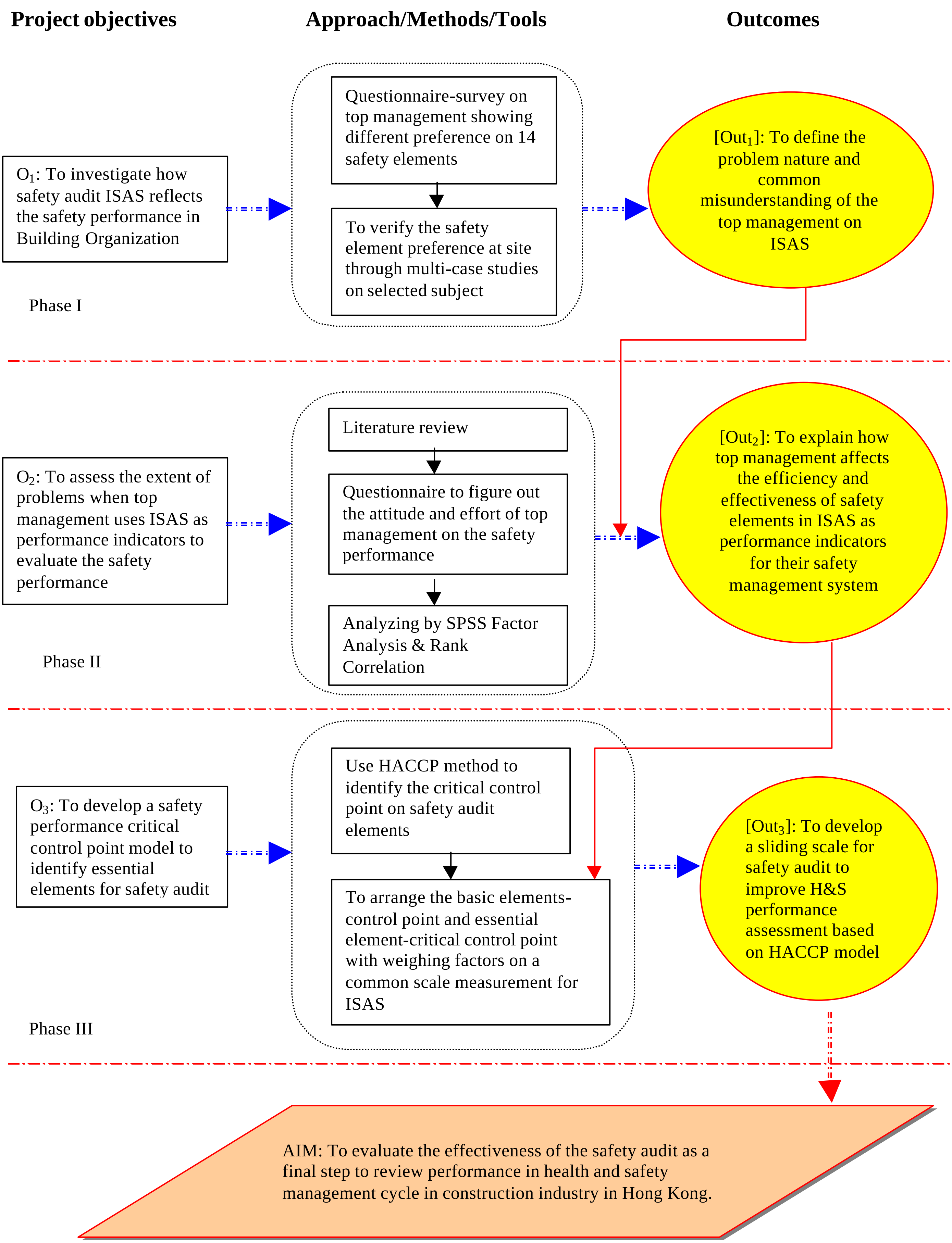
The research tools are through questionnaire-survey with covering letter at appendix I and questionnaire at appendix II, and then retrospective data collection method. The data collected would be analyzed by the statistical means including Factor Analysis and Rank Correlation of Statistical Package for the Social Science (SPSS), and operational software---the excel trend line analysis.

For the first stage of research method, the data collected from question number 13 of the questionnaire providing information on the safety priority of 14 SEs viewed by top management's preference are compared with the quarterly audit score of 14 SEs over a one-year period. It aims at investigating how safety audit ISAS reflects the safety performance of SMS when the building contractors implement their SMS with their safety preference. In essence the problem area if any can be identified and defined.

With respect to the second stage, data collected from questions 4 to 11 of the questionnaire will be used for analyzing the suspected factors namely effort and attitude of top management affecting the effective implementation of the SMS. The results of this analysis is used for assisting the development of an improvement method for ISAS to truly assess the safety performance of the safety management system.

Finally HACCP is used for classifying the 14 safety elements of ISAS safety audit into two-tier performance indicators. The first tier performance indicator are the control point indicators CPI to secure effective implementation of safety management system. The second tier of performance indicator is critical control point indicator ensuring continuous improvement.

**Figure 3 Study Design of the research method showing the overall approach to the project**



## RESEARCH METHODS/TOOLS

The research methods used here are through questionnaire-survey and retrospective data collection.

### Questionnaire-Survey

The questionnaire-survey is conducted through a mailing list of the building contractors registered under Buildings Department of Hong Kong Special Administrative Region Government at Gazette Notice 152 of 1999. The contractors are asked to voluntarily answer the questionnaire at appendix I with a covering letter at appendix II. The purpose of the questionnaire is to get background information of building industry, data about safety effort and attitude held by top management as well as priority of 14 safety elements of ISAS as regarded by top management's preference.

### Focus of Questionnaire

There are altogether 13 questions set in the questionnaire. From question 1 to 3 and 12, they aim at getting background information of the building industry in Hong Kong. As for questions 4 to 11, they are used for evaluating the factors namely effort and attitude of top management towards implementation of safety management. With respect to the last question number 13, it focuses on unveiling the top management's preference when discharging safety management duties in terms of 14 safety elements of mandatory safety audit.

### Retrospective Data Collection

12 construction companies are invited at convenient basis to participate in the study. They are required to submit the past one-year safety audit score from the period

between end of 1998 to early 2000. It is expected that altogether there will be 48 quarterly safety audit reports for data analysis. In this connection, the actual safety trend from on-site study will be compared with the safety trend as viewed by top management's preference as obtained from the questionnaire-survey.

**ANALYTICAL TOOL:**

The research methodology is to fit the study design in three phases. In view of huge amount of data collected from questionnaire-survey, a statistical packages for the social science (SPSS) is adopted. Based on the setting of null hypothesis as at Chapter 4, factor analysis and rank correlation are regarded as most suitable tool in this situation. The other analytical tool will be 'excel' trend line analysis. The 14 safety elements viewed by the top management's preference and on-site safety element trend are depicted in histogram with a best trend line drawn by excel. It is thought that the excel best trend line would best present the result when comparing these two safety trends viewed by top management and shown by actual on-site audit score.

# CHAPTER 6 SAMPLING

**MAILED QUESTIONNAIRE:**

420 building contractors registered under Buildings Department at Gazette Notice 152 of 1999 are invited to participate the research study from mid-July to early August 2000. This exercise covers the whole population size to answer the questionnaire with purpose statement and a stamped-returned-addressed envelop.

The survey in form of 13-question questionnaire is mainly designed to check out whether or not the effort and attitude of top management affects the safety performance of related matters at building sites. Of which the purpose of evaluation proposed in the questionnaire are indicated at table 1.

Table 1 study focus of questionnaire

| **Variables** | | **Indication** |
|---|---|---|
| **Effort** | Q4 contract sum spent on safety | Top management commitment to safety |
| | Q5 No. of summons to have been prosecuted over the past 3 years | Outcome of effort |
| | Q6 No. of site being looked after by SO | Status and responsibility of safety personnel |
| | Q7 top management sponsor staff to attend safety training | Importance of safety training |
| **Attitude** | Q8 top management staff participate the survey | Top management attitude to safety |
| | Q9 Top management attending safety meeting | Importance of safety committee viewed by top management |
| | Q10 Accident target rate set in the safety policy | Correct attitude to safety with realistic/achievable target |
| | Q11 top management taken pro-active either or post-active safety action | Commitment to continuous improvement in safety |

## RETROSPECTIVE DATA COLLECTION

The retrospective data collection is chiefly concerned with the score of the safety audit measuring the safety performance of the building organization. 12 out of 420 building contractors are conveniently chosen based on their voluntary participation for this study. They are asked to submit the past one-year quarterly safety audit records from any one-year period between 1998 to 2000. Therefore any other factor external or intervening variables to the study could be frozen. In essence, the only concerned factor of the On-site safety performance in terms of the extent of compliance of 14 SEs could be identified.

## UNIT OF MEASUREMENT

The level of measurement in the study will be of two types. One is concerned about the questionnaire and the other is concerned with retrospective data analysis. As for the question 1 to 12 in the questionnaire, both nominal data getting background information and ordinal data focusing on the dependent and independent variables are collected. The last question number 13 is to obtain ordinal data as well when the participants are asked to rank the 14 safety elements with 1 as the most important and 14 as the least important choice. Of course, they are free to rank all these safety elements as most important when discharging their safety and health duty.

With respect to the retrospective data study on the quarterly safety audit score from 12 construction companies, the measurement is ordinal as well. This is because all these 14 safety elements of ISAS have been checked by about 450 questions about the safety and health management of the construction site. For compliance, 1 mark is given and '0' for non-compliance in ISAS. The percentage of compliance responsible for each safety element is finally computed. The extent of compliance for each safety element is presented on the same percentage scale. The weighing factor of each safety element is equal. That is to say there is an equal standpoint to judge the compliance of each safety elements of the ISAS.

# CHAPTER 7

# RESULT: BACKGROUND INFORMATION FROM QUESTIONNAIRE-SURVEY

420 building contractors registered as Registered General Building Contracts under Department of Buildings at Gazette Notice 152 of 1999 have been invited through mail to participate this survey in mid-July. 13 mails are returned by the Post Office due to either companies moved out or no such addressees. Out of 407 building contractors, there are 103 respondents. The respondent rate is therefore 25.3 percent.

**Method of interpretation:**

From the reply, it is noticed that not all the questions set in the questionnaire have been fully answered by the respondents. Only the valid data with respect to data from the fully answered questions are considered in this study.

**Method of sending out questionnaire by the respondents**

Table 2 Types of reply

| | |
|---|---|
| **Valid** | **103** |
| Missing | 0 |

Types of reply

| | method | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **By post** | 78 | 75.7 | **75.7** | 75.7 |
| | By fax | 25 | 24.3 | 24.3 | 100.0 |
| | Total | 103 | 100.0 | 100.0 | |

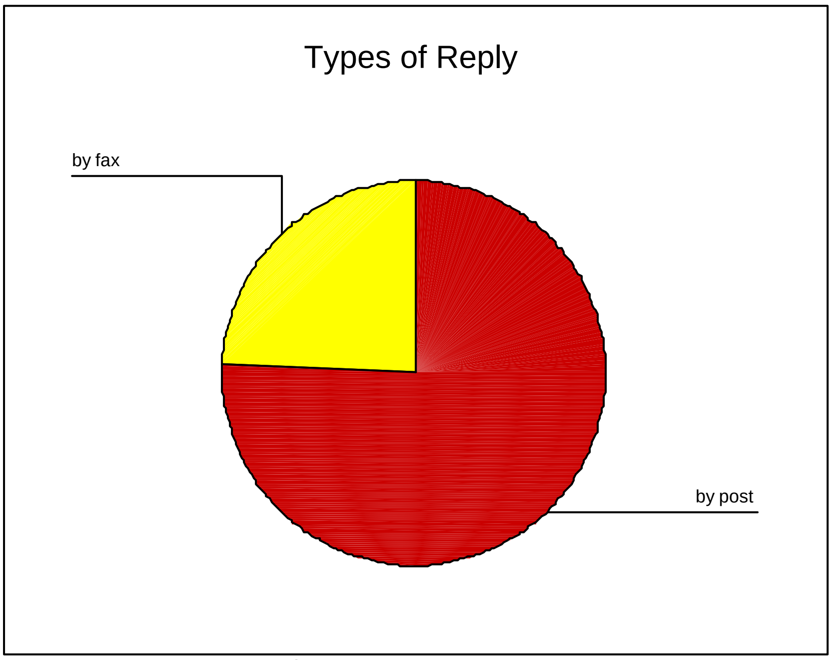



Figure 4 Types of reply

From the types of reply, there are around **76% replied by post** with stamped self-addressed envelop (SSAE), whereas around 24% replied by fax. It is considered that the contractors would like to adopt a more conservative way of sending out reply through SSAE.

**Question 1: nature of building work**

Table 3 Nature of building work held by the building contractors

| | | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=main contractor** | 99 | 96.1 | **97.1** | 97.1 |
| | 2=sub-con | 2 | 1.9 | 2.0 | 99.0 |
| | 3=joint venture | 1 | 1.0 | 1.0 | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0=missing value | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

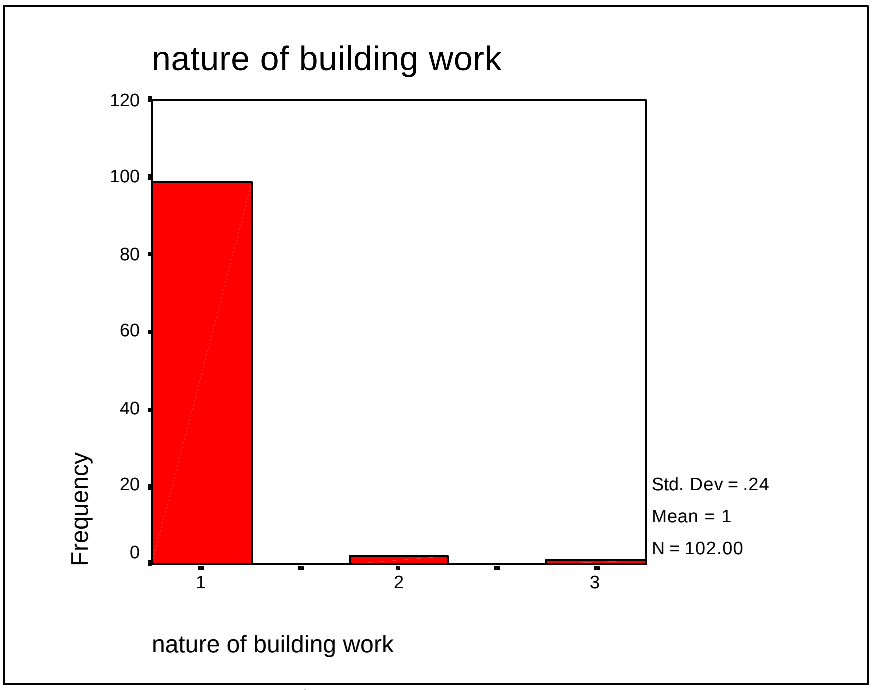



Figure 5 Nature of building work held by building contractors

Around **97% respondents are main contractors**. It is believed that the high respondent rate from main contractors is due to the legal liability imposed on the main contractors instead of sub-contractors referring to Occupational Safety and Health Ordinance, Factories and Industrial Undertakings Ordinance and their subsidiary legislation.

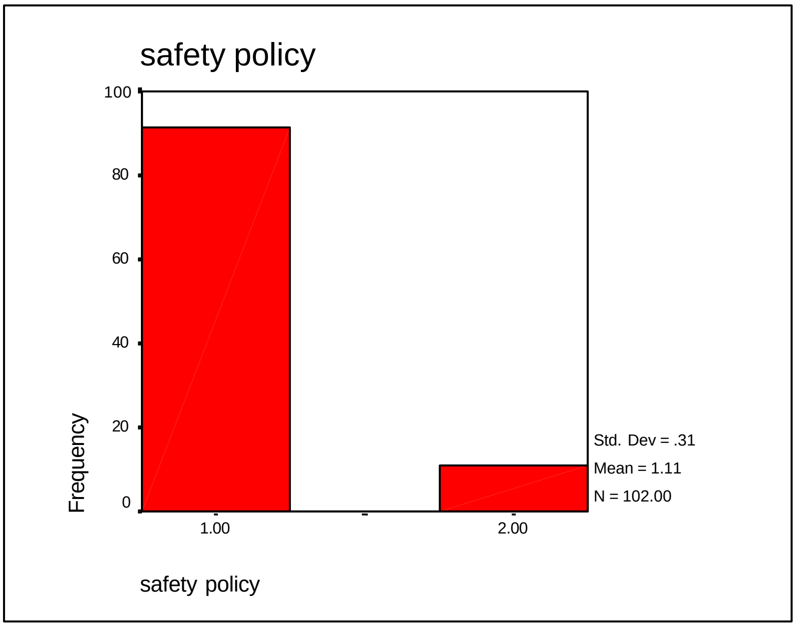
**Question 2: safety policy**

Table 4 Building Contractors with Safety policy

| | Types of answer | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=yes** | 91 | 88.3 | **89.2** | 89.2 |
| | 2=no | 11 | 10.7 | 10.8 | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0=missing | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

Around **89% respondents have their workplace safety policies**. Therefore 11% have no workplace safety policy and it is believed that they have the SP not down to the floor shop.

Figure 6 building contractor with safety policy



**Question 3: contract size**

Table 5 Contract size

| | Types of contract size | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=0.8 billion or more** | 31 | 30.1 | **30.4** | 30.4 |
| | 2=0.6 to <0.8 billion | 9 | 8.7 | 8.8 | 39.2 |
| | 3=0.4 to < 0.6 billion | 11 | 10.7 | 10.8 | 50.0 |
| | 4=0.2 to <0.4 billion | 14 | 13.6 | 13.7 | 63.7 |
| | **5=<0.2 billion** | 37 | 35.9 | **36.3** | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0=missing | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

**Two types** of contract sizes are found to **dominate in this study**.

Around 30% of contract size is **0.8 billion or more**; and around 36% contract size is **less than 0.2 billion**. These imply that the market situation is dominated by two types of building job around 1 block and 6 blocks building contracts in the construction sites.

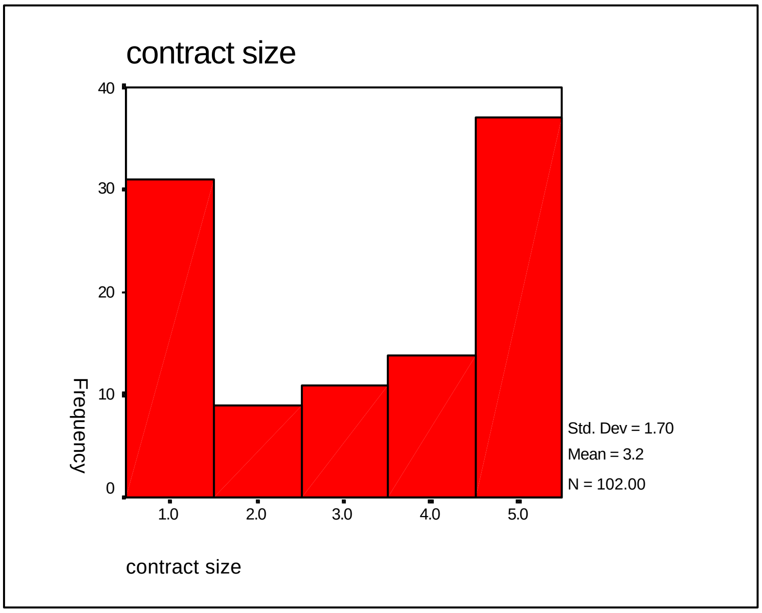



Figure 7 Contract Size

**Question 4: contract sum spent on safety**

Table 6 Contract sum spent on safety

| | The amount of contract sum to be spent on safety | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | 1=>2% | 4 | 3.9 | 3.9 | 3.9 |
| | **2=1% to < 2%** | **23** | **22.3** | **22.5** | 26.5 |
| | **3=0.5% to < 1%** | **27** | **26.2** | **26.5** | 52.9 |
| | **4=0.25% to < 0.5%** | **27** | **26.2** | **26.5** | 79.4 |
| | **5=< 0.25%** | **21** | **20.4** | **20.6** | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0 | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

The contract sum spent on safety at workplace is found evenly distributed ranging from 20% to around 27% for the categories from 2 to 5. That is to say the **contractors would like to spend from less than 0.25% to less than 2% of the contract sum for safety**. There is less than 4% the contractors would spend more than 2% of the contract sum.

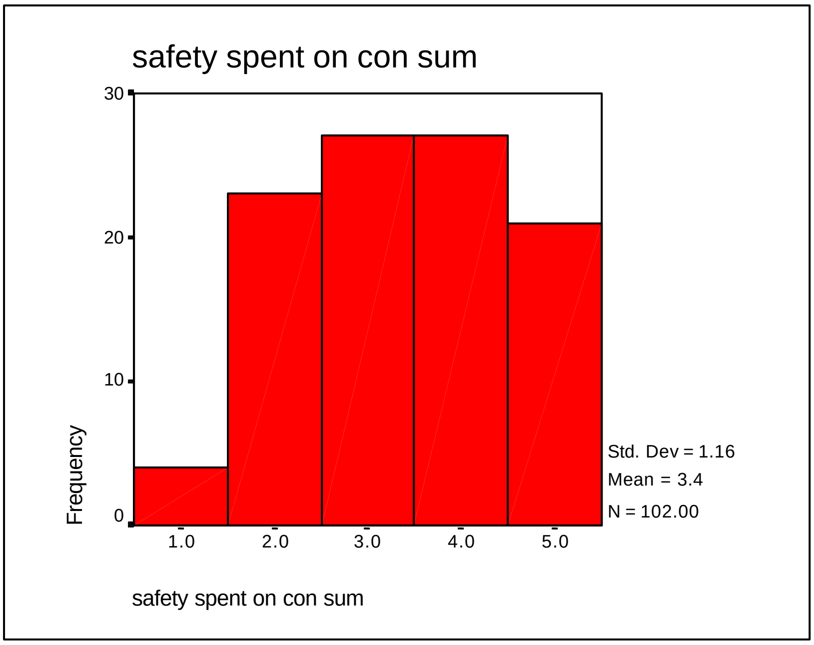



Figure 8 Contract sum spent on safety

In this connection it is understood that when the contract size in this study is dominated by less than **0.2 billion as well as 0.8 billion or more, the contractors are more or less likely spent 0.25% to 2% of the contract sum**. With this regard, it can show in two interesting propositions or scenarios.

If the current market situation in year 2000 is taken into consideration, the salary of a safety manager, a safety officer and a safety supervisor will be at respective HK$40,000, HK$30,000 and HK$15,000. In this regard, the contract sizes with 0.2 and 0.8 billion lead to deploy the following safety personnel and budget for safety equipment:

Table 7 Evaluation of potential problem with contract sum and contract size

| % of contract sum spent on safety | Contract size | | | | | |
|---|---|---|---|---|---|---|
| | **0.2 b** (for 1-block building site) | | | 0.8 b (for 6-block building site) | | |
| | Actual spent for 2-year project (HK$) | Actual monthly spent on safety (HK$) | Monthly safety spent break-down | Actual spent for 2-year project (HK$) | Actual monthly spent on safety (HK$) | Monthly safety spent break-down |
| **0.25%** | 0.5m | ~20,000 | **1 SO part-time** | 2m | ~80,000 | 1 SO<br>2 SS<br>E($20,000) |
| 0.5% | 1m | ~40,000 | 1 SO<br>E($10,000) | 4m | ~160,000 | 1 SM<br>2 SO<br>2SS<br>E($30,000) |
| 1% | 2m | ~80,000 | 1 SO ;<br>1 SS;<br>E($25,000) | 8m | ~320,000 | 1 SM<br>2 SO<br>4 SS<br>E($30,000)<br>First aid room (safety team) |
| 2% | 4m | ~160,000 | 1 SM<br>1SO<br>2SS<br>E($60,000) | 16m | ~640,000 | 1 SM<br>2 SO<br>4 SS<br>E($30,000)<br>First aid room (safety team) |
| *Key:b(billion); m(million); E(equipment); SO(safety officer); SM(safety manager)* | | | | | | |

From the interpretation of result arising from questions 3 and 4, it is noticed that the contract size of **0.2 billion with contract sum spent safety less than 0.25% will most likely have problems in handling the safety matters at site**. It is because only a part-time safety officer will be working on the one-block building site.

**Question 5: no of summons**

Table 8 Number of summons having been issued over the past 3 years

| | No. of summons | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=0** | 25 | 24.3 | **25.0** | 25.0 |
| | **2=1 to 5** | 46 | 44.7 | **46.0** | 71.0 |
| | 3=6 to 10 | 16 | 15.5 | 16.0 | 87.0 |
| | 4=11 to 15 | 4 | 3.9 | 4.0 | 91.0 |
| | 5=over 15 | 9 | 8.7 | 9.0 | 100.0 |
| | Total | 100 | 97.1 | 100.0 | |
| Missing | 0=missing | 3 | 2.9 | | |
| Total | | 103 | 100.0 | | |

**75% of respondents** indicate that they have been **prosecuted** under the health and safety related legislation **over the past 3 years**. The majority around **46% respondents** have been prosecuted for **one to five times**. **9%** of the respondents have been prosecuted for **more than 15 times** which is considered as the most problematic in handling health and safety matter on the site.

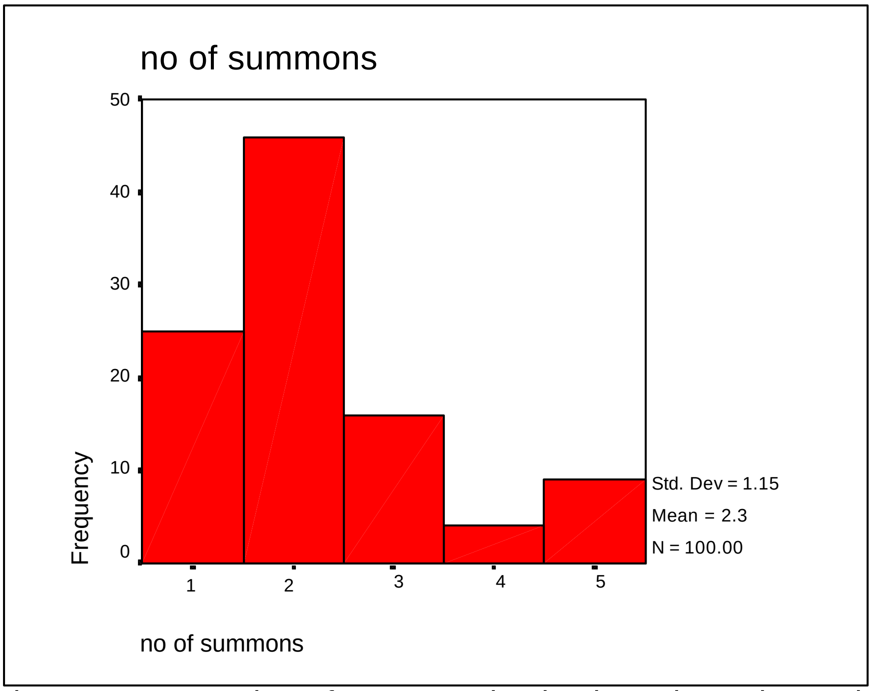



Figure 9 Number of summons having been issued over the past 3 years

**Question 6: no. of site for SO**

Table 9 Number of construction sites assigned for safety officer

| | No. of site to be looked after by an SO | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=1** | 41 | 39.8 | **40.2** | 40.2 |
| | 2=2 | 30 | 29.1 | 29.4 | 69.6 |
| | 3=3 | 22 | 21.4 | 21.6 | 91.2 |
| | 4=4 | 3 | 2.9 | 2.9 | 94.1 |
| | 5=5 | 6 | 5.8 | 5.9 | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0-=missing | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

From the result, there is a majority of around **40%** respondent reply that their safety officers are assigned to **look after one site only**. The workload is regarded as reasonable.

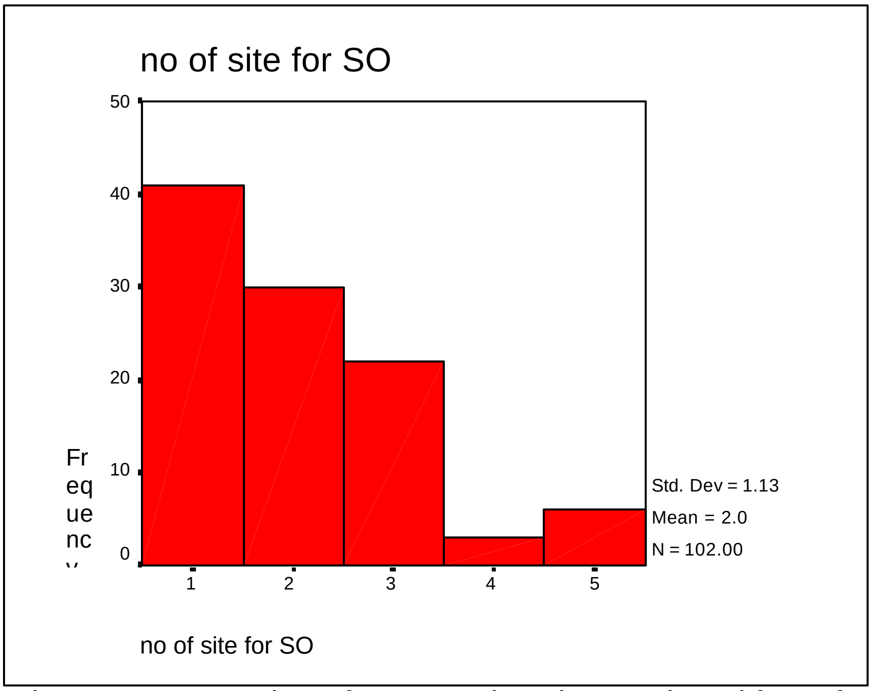



Figure 10 Number of construction sites assigned for safety officer

**Question 7: sponsor for staff training**

Table 10 Top management sponsoring staff on safety training

| | % of sponsorship | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=100%** | 71 | 68.9 | **69.6** | 69.6 |
| | 2=>80% but < 100% | 5 | 4.9 | 4.9 | 74.5 |
| | 3=>50% but <80% | 14 | 13.6 | 13.7 | 88.2 |
| | 4=>20% but < 50% | 10 | 9.7 | 9.8 | 98.0 |
| | 5=zero | 2 | 1.9 | 2.0 | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0=missing | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

It is encouraging to see that 98% of respondents will sponsor staff on safety training.

**Around 70% of respondents indicate that they sponsor 100%** for their staff to attend safety training course.

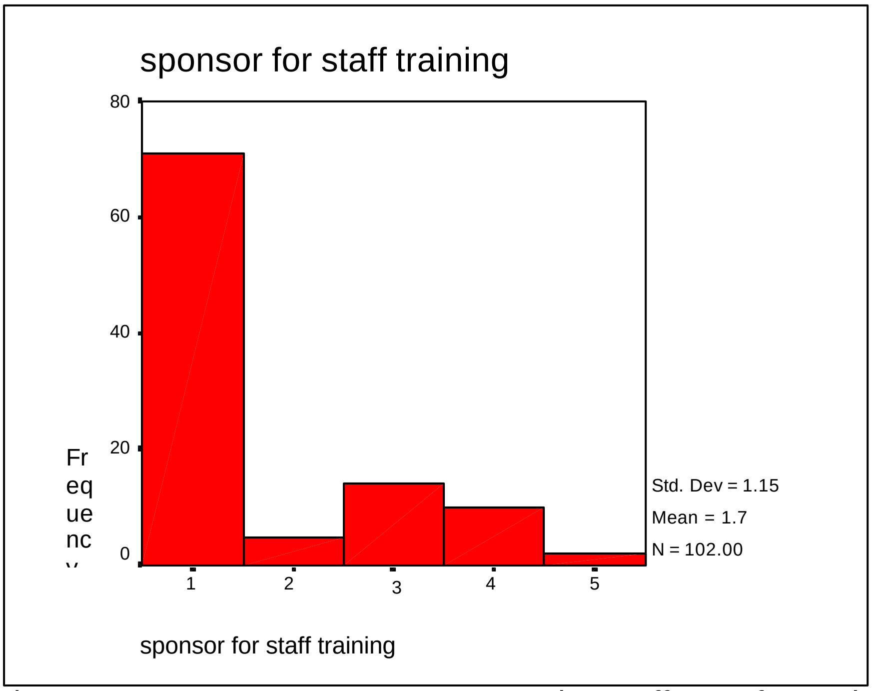



Figure 11 Top management sponsoring staff on safety training

**Question 8: post of participant**

Table 11 Post held by the participants

| | Post held by the respondent | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=Director** | 53 | 51.5 | 52.0 | 52.0 |
| | **2=CEO** | 6 | 5.8 | 5.9 | 57.8 |
| | **3=PM** | 37 | 35.9 | 36.3 | **94.1** |
| | 4=SO | 5 | 4.9 | 4.9 | 99.0 |
| | 5=SS | 1 | 1.0 | 1.0 | 100.0 |
| | Total | 102 | 99.0 | 100.0 | |
| Missing | 0=missing | 1 | 1.0 | | |
| Total | | 103 | 100.0 | | |

The top management is regarded as anyone holding the position of either 1=director; 2=Chief Executive Officer; and 3=Project Manager. In this question, it is noticed that there are altogether **94%** of respondents holding the position of either 1, or 2 or 3 which are all regarded as the level of **top management**. The result of survey is therefore believed to be **best represented** as the aim of the measure of the attitude and effort of the top management.

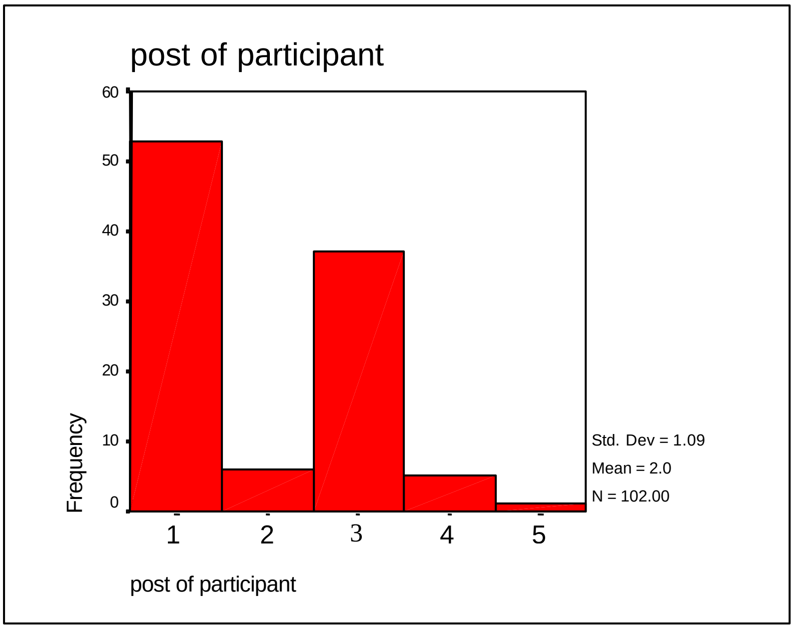



Figure 12 Post held by the participants

**Question 9: top management attend safety meeting**

Table 12 Top management attending safety meeting

| | Attendance of safety meeting | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=always** | 50 | 48.5 | **49.5** | 49.5 |
| | 2=once every 2 | 16 | 15.5 | 15.8 | 65.3 |
| | 3=once every 4 | 8 | 7.8 | 7.9 | 73.3 |
| | **4=ad hoc** | 25 | 24.3 | **24.8** | 98.0 |
| | 5=never | 2 | 1.9 | 2.0 | 100.0 |
| | Total | 101 | 98.1 | 100.0 | |
| Missing | 0=missing | 2 | 1.9 | | |
| Total | | 103 | 100.0 | | |

**98%** respondents reveal they **would attend** safety meeting. However only around **50% would always** attend meeting. **25%** of respondents indicate they attend the meeting on an **ad hoc basis**. These two findings may be useful in analysis of the effort and attitude of the top management on the safety and health matters. Whereas 16% of respondents attend once every 2 meeting and then around 8% of respondents attend the safety meeting once every 4 times.

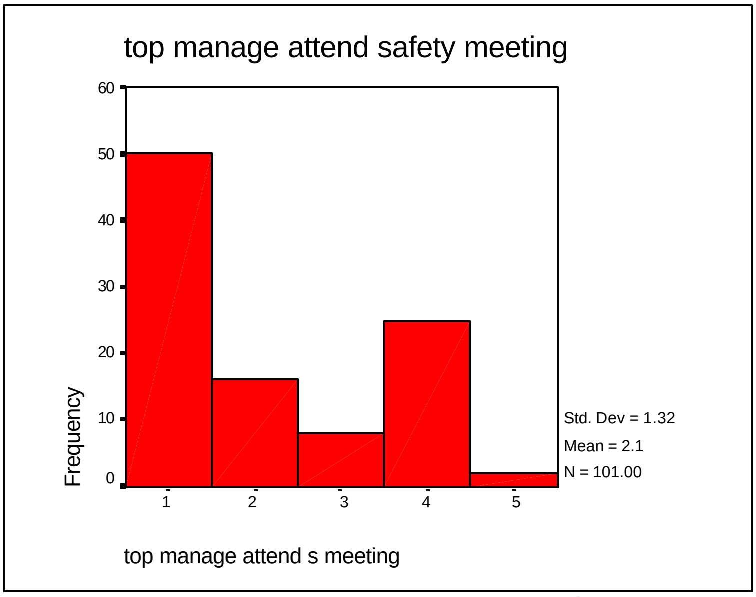



Figure 13 Top management attending safety meeting

**Question 10: accident target in SP**

Table 13 Accident target rate set in the safety policy

| | Safety target on accident rate | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=zero** | 53 | 51.5 | **53.5** | 53.5 |
| | 2=yearly LB acc rate | 5 | 4.9 | 5.1 | 58.6 |
| | 3=<yearly LB acc rate | 27 | 26.2 | 27.3 | 85.9 |
| | 4=previous own record | 1 | 1.0 | 1.0 | 86.9 |
| | 5=< previous own record | 13 | 12.6 | 13.1 | 100.0 |
| | Total | 99 | 96.1 | 100.0 | |
| Missing | 0=missing | 4 | 3.9 | | |
| Total | | 103 | 100.0 | | |

More than half of the respondents revealed around **54% targeted at zero accident rate** in relation to health and safety. It is therefore worth looking at the effort and attitude of the top management spent on health and safety issue.

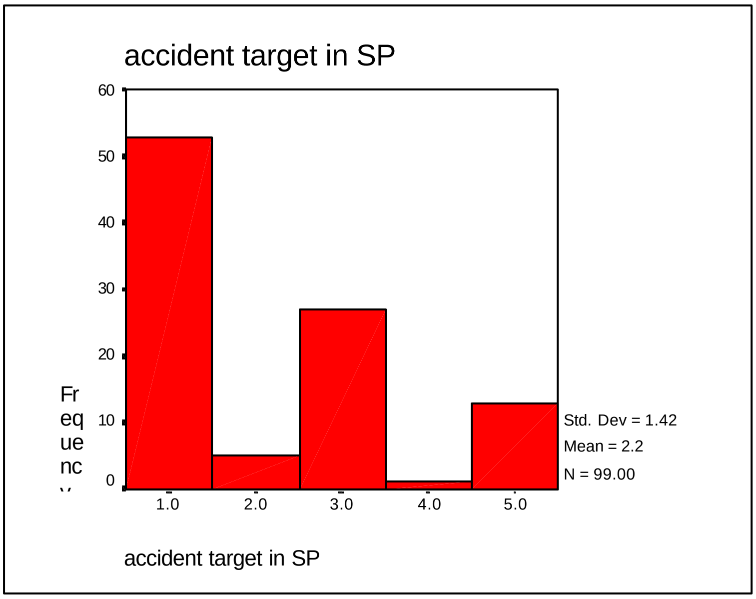



Figure 14 Accident target rate set in the safety policy

## Question 11: biggest effort

Table 14 Biggest effort paid by top management when taking action to ensure health and safety at workplace

| | Types of action | Frequency | Percent | Valid Percent | Cumulative Percent |
|---|---|---|---|---|---|
| Valid | **1=routine** | 68 | 66.0 | **68.0** | 68.0 |
| | 2=after Safety inspection | 19 | 18.4 | 19.0 | 87.0 |
| | 3=prior to Safety Audit | 9 | 8.7 | 9.0 | 96.0 |
| | 4=after acc | 3 | 2.9 | 3.0 | 99.0 |
| | 5=after prosecution | 1 | 1.0 | 1.0 | 100.0 |
| | Total | 100 | 97.1 | 100.0 | |
| Missing | 0=missing | 3 | 2.9 | | |
| Total | | 103 | 100.0 | | |

There is no right or wrong answer to this question. However, it is considered that if effort will flow into the situation like after prosecution and accident, it is deemed as post-active. Or if the effort is focused on preparation before safety audit, the intention is suspected as getting passing score instead of targeting at continuous improvement.

From the reply of this question, it is noticed that the majority of **68%** respondents reveal that they **pay effort as routine work**. It is a good indication that the action taken by the top management is continuous and consistent.

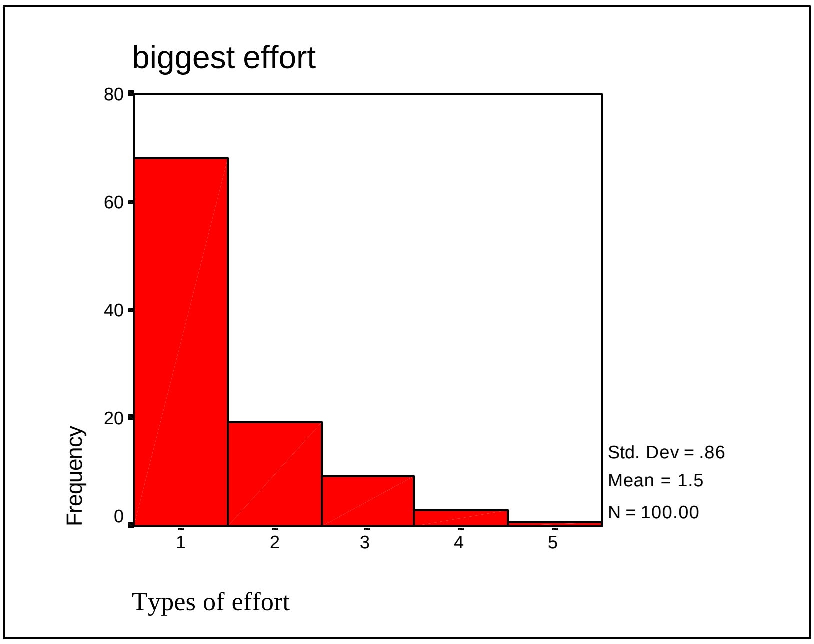



Figure 15 Biggest effort paid by top management when taking action to ensure health and safety at workplace

**Question 13: the priority of 14 safety element in the safety audit**

Table 15

| | | ranking for safety policy | org | training | rules | program for hazard inspn | PP program | accident & investigation | emergency preparedness |
|---|---|---|---|---|---|---|---|---|---|
| N | Valid | 95 | 94 | 94 | 94 | 94 | 93 | 93 | 94 |
| | Missing | 8 | 9 | 9 | 9 | 9 | 10 | 10 | 9 |
| Mean | | 3.83 | 4.48 | 3.32 | 5.56 | 7.36 | 7.02 | 10.08 | 9.53 |
| **Median** | | **2.00** | **3.00** | **3.00** | **5.00** | **7.00** | **7.00** | **11.00** | **10.00** |
| Std. Deviation | | 3.77 | 3.17 | 2.47 | 3.22 | 3.18 | 3.44 | 3.35 | 3.27 |
| Variance | | 14.21 | 10.08 | 6.11 | 10.40 | 10.10 | 11.83 | 11.24 | 10.66 |
| Minimum | | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Maximum | | 14 | 14 | 11 | 14 | 14 | 14 | 14 | 14 |

| | | safety comm | control of sub-con | job hazard analysis | safety promotion | process control program | health assurance prog |
|---|---|---|---|---|---|---|---|
| N | Valid | 94 | 94 | 93 | 95 | 94 | 93 |
| | Missing | 9 | 9 | 10 | 8 | 9 | 10 |
| Mean | | 6.99 | 7.71 | 8.17 | 8.34 | 9.06 | 11.47 |
| **Median** | | **6.50** | **7.00** | **9.00** | **8.00** | **10.00** | **12.00** |
| Std. Deviation | | 3.47 | 3.81 | 3.42 | 3.70 | 3.68 | 2.90 |
| Variance | | 12.01 | 14.51 | 11.69 | 13.72 | 13.54 | 8.43 |
| Minimum | | 1 | 1 | 1 | 1 | 1 | 1 |
| Maximum | | 14 | 14 | 14 | 14 | 14 | 14 |

The findings to question 13 reveal that the 14-safety elements ranked from 2 to 12 indicate different top management's preference on the safety elements when discharging safety and health duties to fulfill safety audit. The **lower the value**, the **higher ranking in priority** as viewed by the top management as set in the questionnaire.

## SUMMARY OF RESULT ON BACKGROUND INFORMATION

Table 16 summary of background information on building industry

| **GENERAL** | | **PREFERENCE OF CHOICE** |
|---|---|---|
| Q1: Nature of work | = | 1 (main contractor 97%) |
| Q2 Building contractors with safety policy | = | 1 (workplace Safety Policy 89%) |
| Q3 Contract size | = | 1 (0.8 billion or more 30.4%) |
| | = | 2 (<0.2 billion 36.3%) |
| **EFFORT** | | |
| Q4 contract sum spent on safety | = | 5 (<0.25% of contract sum ~21%) |
| Q5 No. of summons having been | = | 1 (zero prosecution 25%) |
| prosecuted | = | 5 (over 15 prosecution 9%) |
| Q6 No. of site looked after by SO | = | 1 (1 site 40.2%) |
| Q7 top management sponsor for safety training | = | 1 (absolute sponsor ~70%) |
| **ATTITUDE** | | |
| Q8 94% top management staff participate the survey | | |
| Q9 Top management attending safety meeting | = | 1 (always 50%) |
| | = | 4 (ad hoc 25%) |
| Q10 Accident target rate | = | 1 (zero 54%) |
| Q11 Biggest effort | = | 1 (Routine 68%) |

The data obtained from question 12 could not be used for this study. It is because more than one choice is allowed for the question that makes it complicated for analysis.

As for question 13, the preferences on safety elements may arouse suspicion on fair allocation of resources to these 14 safety elements when top management discharge safety management duties.

# CHAPTER 8

# ANALYSIS OF RESULT I: IDENTIFICATION OF PROBLEM OF TOP MANAGEMENT ON ISAS

## STEP 1:

## QUESTIONNAIRE-SURVEY ON TOP MANAGEMENT OF BUILDING CONTRACTORS SHOWING PREFERENCE ON 14 SAFETY ELEMENTS

The data used here are obtained from question 13 in the questionnaire-survey. The 103 participants answer voluntarily to give their preference in ranking the safety elements of the safety audit when discharging their safety management system. Among the replies, 2 are invalid due to incomplete answer.

Having analyzed the data in table 15, the corresponding mean value of priority for each safety element is used for analysis of the weighing priority for the 14 safety elements. In order to facilitate the interpretation, the14 safety elements are put in the x-axis in descending order of priority. The weighing priority value indicated in the y-axis shows that the higher the value, the higher the priority is.

From figure 16 the highest value of 13 is scored by the safety element of safety policy, whereas the lowest value of 3 is scored by the safety element of health assurance programme. The top management preference to the safety elements are arranged in descending order with priority value in the bracket as follows:

They are

Safety policy (13);

Safety training (12);

Safety organization (12);

In-house rules & regulations (10);

Evaluation, selection and control of sub-contractor (8);

Programme of inspection for a hazardous condition (8);

personal protection programme (8);

safety committee (7.5);

safety promotion (6.5);

job hazardous analysis (6);

emergency preparedness (5);

process control programme (5);

accident & incident investigation (4); and

health assurance programme (3).

A best trend line is also drawn by excel for easy interpretation of the trend of top management preference.


**Figure 16 Top Management Weighing the Priority of 14 Safety Elements in Safety Audit for Building Industry**

**STEP 2:**

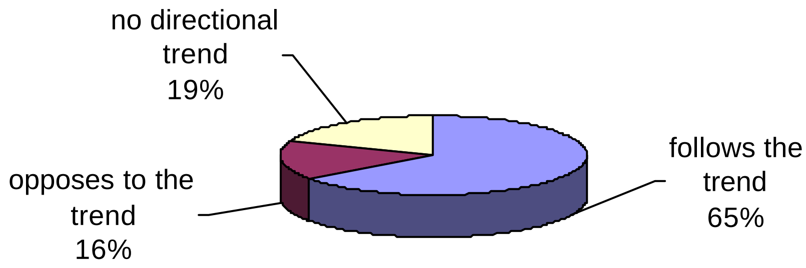
**VERIFICATION OF THE SAFETY ELEMENT PREFERENCE AT SITE THROUGH MULTI-CASE STUDIES ON SELECTED SUBJECT**

The select subjects for this study---12 construction companies have provided the past one-year safety audit reports over the period of 1998 to 2000 for this study. Only 43 instead of 48 quarterly reports have been received. However, each construction company can at least submit three quarterly reports for this study.

The score of 14 safety elements in the quarterly safety audit reports have been computed and plotted according to the priority weighing pattern viewed by top management's preference as obtained in the questionnaire-survey as shown in figure 16. The on-site safety elements' preference are depicted in histograms with a best trend line drawn by excel are depicted at figure 17 to 59. A full set of data for these histograms is located in appendix III.

The trend of quarterly safety element score of each quarterly report is compared with the trend found in the questionnaire-survey.  The summary of findings are shown at figure 60 with information as follows:

**Figure 60   The on-site priority trend of the one-year quarterly ISAS score Vs Safety Elements at 12 Site Areas**



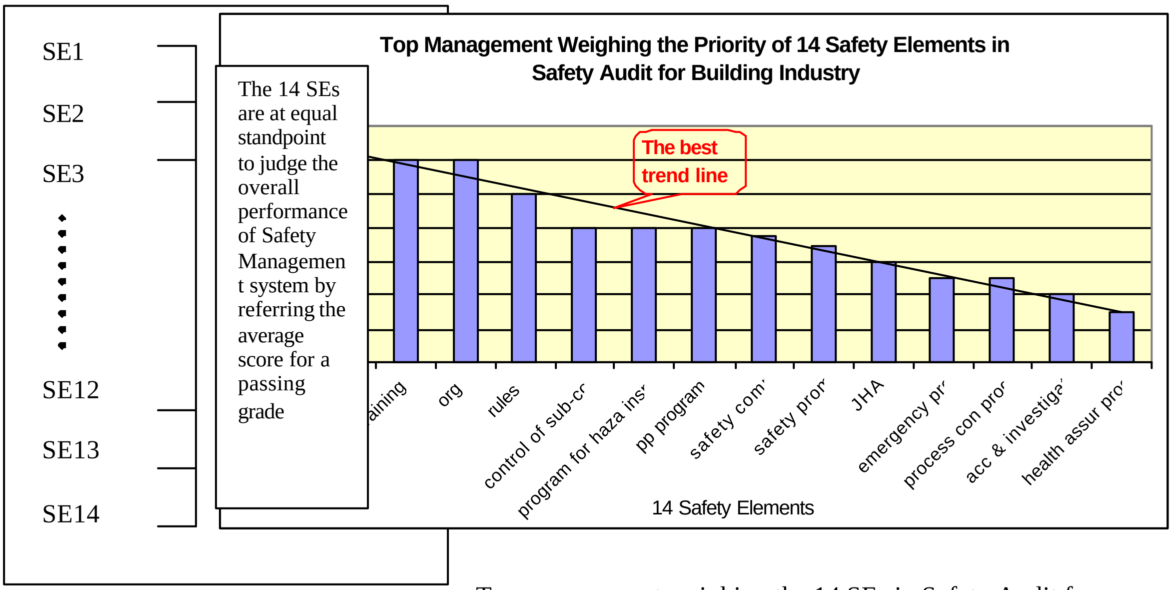

- 28 out of 43 or 65 percent of quarterly reports follow with the trend revealed in the survey.
- 8 out of 43 or 19 percent of the quarterly reports do not show any directional trend that it seems equal attention is paid to all 14 elements.
- Only 7 out of 43 or 16 percent oppose to the trend indicated by the survey.

From the finding it is believed that the on-site safety element priority follows the trend viewed by the top management's preference.  The on-site employees therefore obeyed very well the instruction given by top management.

**OUTCOME OF ANALYSIS OF RESULT AT PHASE I**

There is confidence to say that the trend of the on-site safety element priority follows well with the top management's preference on safety element priority.  Resources and effort may be allocated to the 14 SEs accordingly as well.

The equal weighing factor for 14 SEs employed in the mandatory safety audit could not reveal different effort and attitude held by the top management towards these 14 SEs. The corresponding findings are evident in figure 61. Therefore, some safety elements are received better effort or attitude from top management. In other words, some safety elements have better correlation with either effort or attitude.




Existing System

Top management weighing the 14 SEs in Safety Audit for construction industry

Figure 61 Comparison of mandatory ISAS with equal standpoint of elements with top management's preference on 14 safety elements priori

# CHAPTER 9

# ANALYSIS OF RESULT II:

# IMPROVEMENT OF ISAS BY HACCP

## STEP 1: IDENTIFICATION OF THE CRITICAL CONTROL POINT FOR SAFETY AUDIT ELEMENTS BY HACCP METHOD

In order to improve the effectiveness of ISAS as a performance indicator, all 14 safety elements are gone through the HACCP decision tree as indicated at figure 1 to identify two-tier performance indicators. They are control point indicator (CPI) assessing the effective implementation and critical control point indicator (CCPI) measuring continuous improvement of the safety management system. The 14 safety elements answering the working process of HACCP decision tree are summed up at table 17. As a result 5 safety performance indicators known as CCPI have been identified as follows:

- ✓ Safety training
- ✓ Job hazard analysis
- ✓ Emergency preparedness
- ✓ Health assurance programme
- ✓ Process control programme.

Table 17 Identification of the safety performance indicators---critical control point indicator by a well-defined process known as HACCP.

| 14 safety elements of ISAS | HACCP DECISION TREE | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Q1 | | Q2 | | Q3 | | Q4 | |
| | Yes | No | Yes | No | Yes | No | Yes | No |
| | Q2 | Not CCP | CCP | Q3 | Q4 | Not CCP | Not CCP | CCP |
| Safety policy | | ✓ | | | | | | |
| Safety organization | | ✓ | | | | | | |
| Safety training | ✓ | | ✓ | | | | | |
| In-house rules & regulations | ✓ | | | ✓ | ✓ | | ✓ | |
| Safety committee | ✓ | | | ✓ | ✓ | | ✓ | |
| Programme for inspection of hazardous conditions | ✓ | | | ✓ | | ✓ | | |
| Job hazard analysis | ✓ | | ✓ | | | | | |
| Personal protection programme | ✓ | | | ✓ | ✓ | | ✓ | |
| Accident/ incident investigation | | ✓ | | | | | | |
| Emergency preparedness | ✓ | | | ✓ | ✓ | | | ✓ |
| Safety promotion | | ✓ | | | | | | |
| Health assurance programme | ✓ | | ✓ | | | | | |
| Evaluation, selection & control of sub-contractor | ✓ | | | ✓ | ✓ | | ✓ | |
| Process control programme | ✓ | | ✓ | | | | | |

*Note: The table shall be read with the HACCP decision tree at figure 1.*

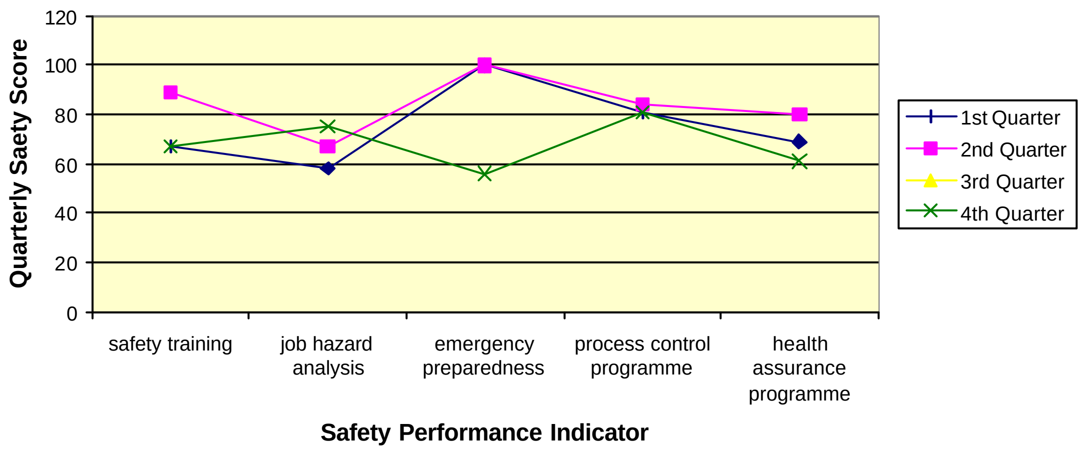
For the ISAS to be effective, a pre-requisite requirement referring to an effective implementation of the safety management system should be in place. The rest of 14 safety elements are deemed as CPIs which are important to assess the effective implementation of a safety management system.

## FEASIBILITY OF HACCP TO CLASSIFY 14 SAFETY ELEMENTS INTO TWO-TIER PERFORMANCE INDICATORS, CPI AND CCPI

In order to check the reliability and validity of the CCPIs identified by HACCP, the one-year quarterly safety audit score that submitted by the 12 building contractors are further studied. The corresponding one-year quarterly safety scores of these 5 safety elements classified as CCPIs for each construction site are analyzed and computed in the form of histograms. In this connection, altogether 12 figures showing the past one year safety performance in terms of CCPIs of the respective 12 building construction sites are depicted in figure 62 to figure 73.

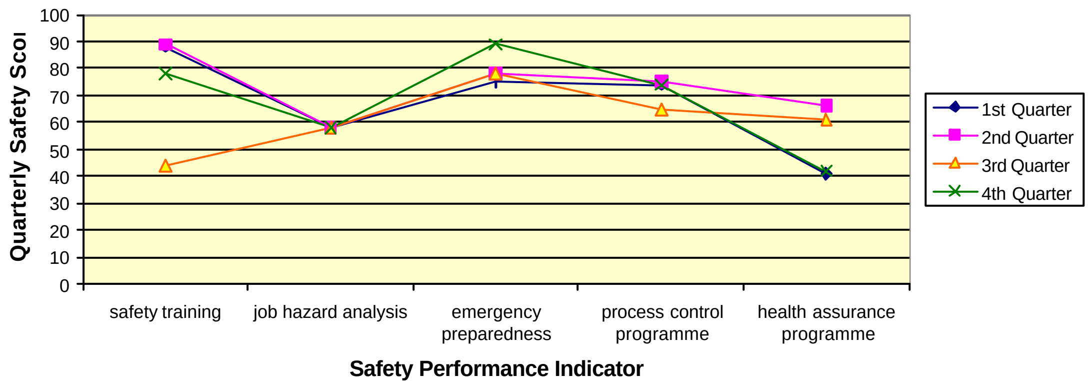
**The safety patterns for 12 different building sites showing the safety score of the performance indicators selected by HACCP**

Figure 62 Individual Safety Score Vs Safety Performance Indicator by HACCP at Site 1

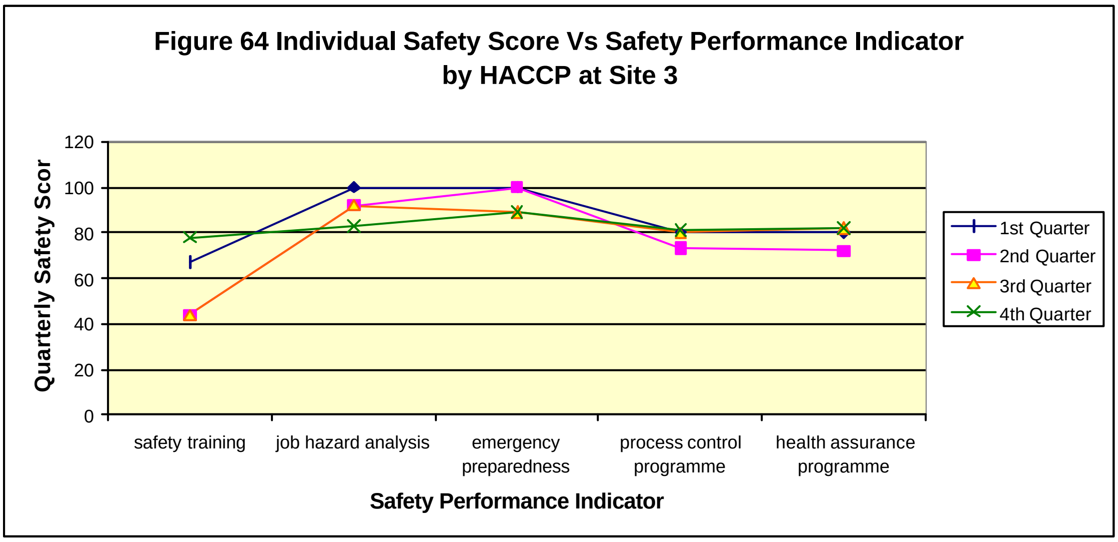



Comment 1: the safety score of the process control programme out of 5 CPIs shows no progress over the one-year quarterly safety audit.

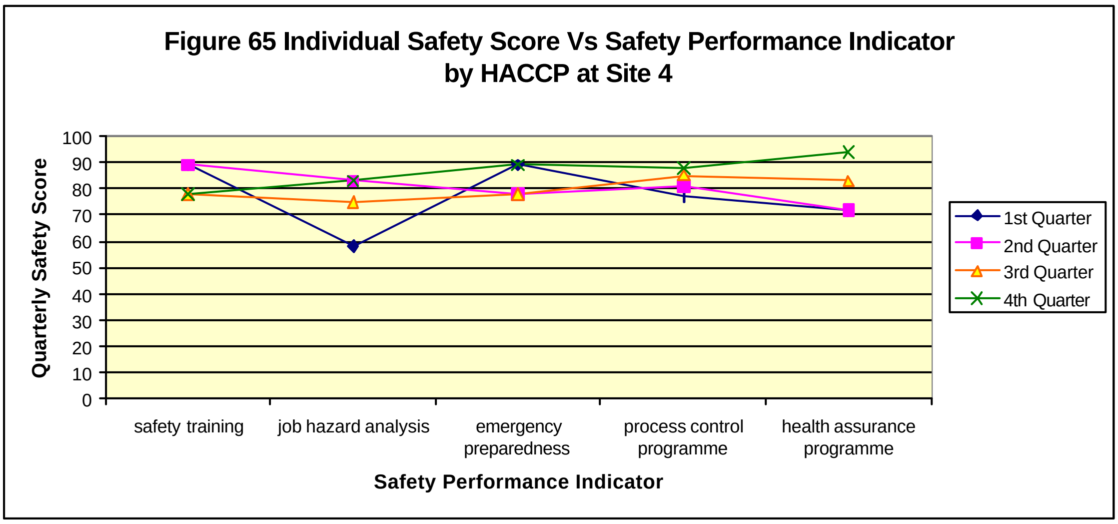
Figure 63 Individual Safety Score Vs Safety Performance Indicator by HACCP at Site 2



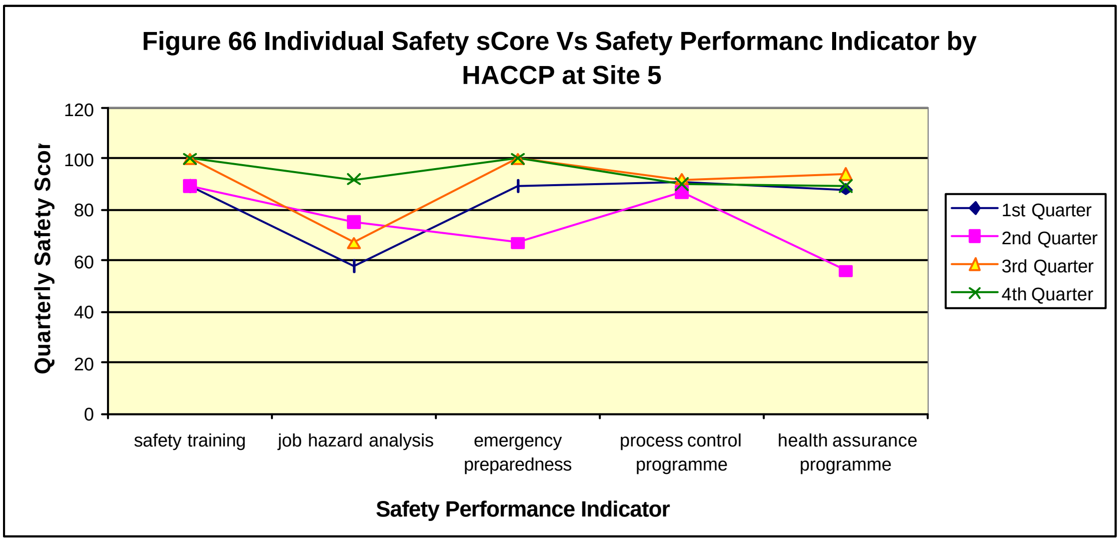

Comment 2: 3 out of 5 CPIs (namely job hazard analysis, emergency preparedness and process control programme) show consistent score pattern over the past one-year safety audit. Furthermore the score of job hazard analysis did not show any improvement at all.



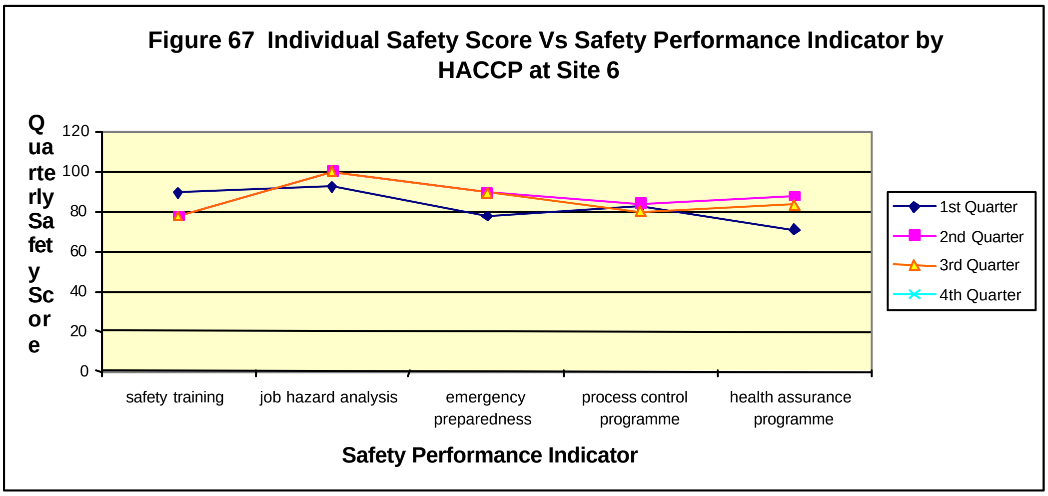

Comment 3: the performance trend over one-year quarterly safety audit is quite consistent. 2 out of 5 CPIs (namely process control programme and health assurance programme) show little change in performance score.



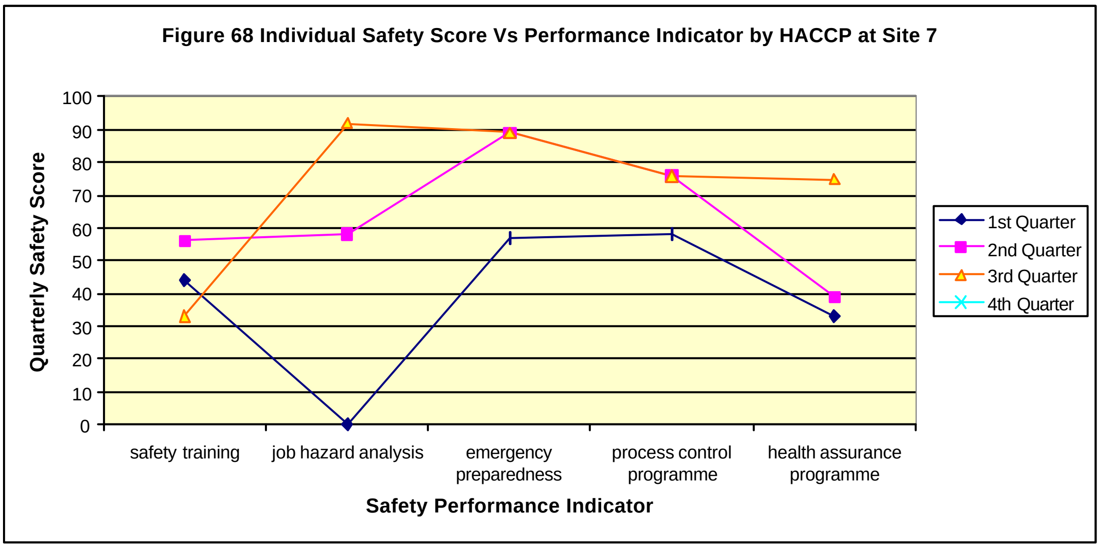

Comment 4: the improvement in safety performance on these five CPIs has been witnessed over the one-year quarterly safety audit.



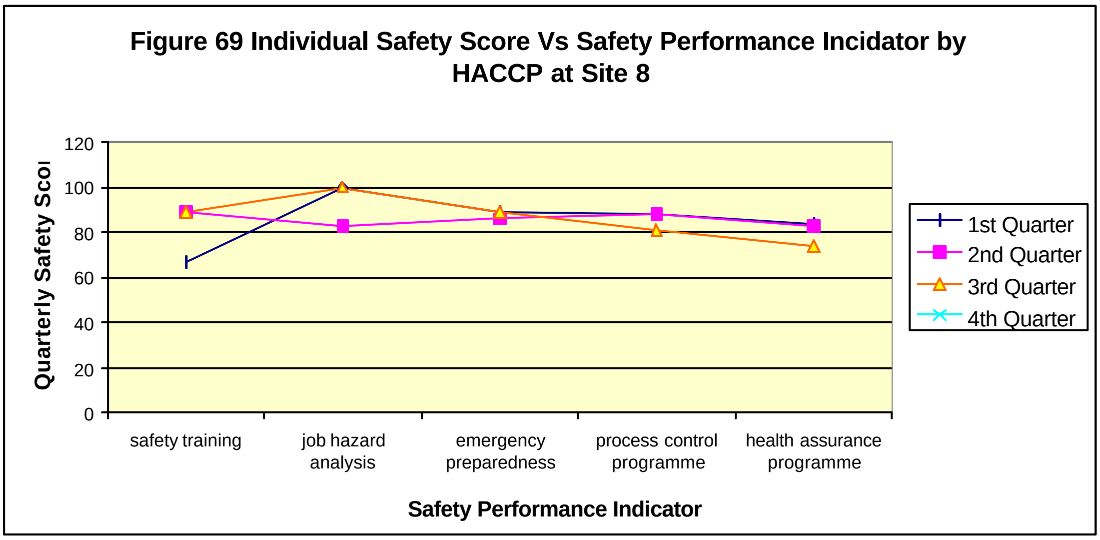

Comment 5: the directional safety performance trends have been evident except the 2nd quarterly audit. In addition, 1 out of 5 CPIs (namely process control programme) reveals little progress in the safety performance over one year.



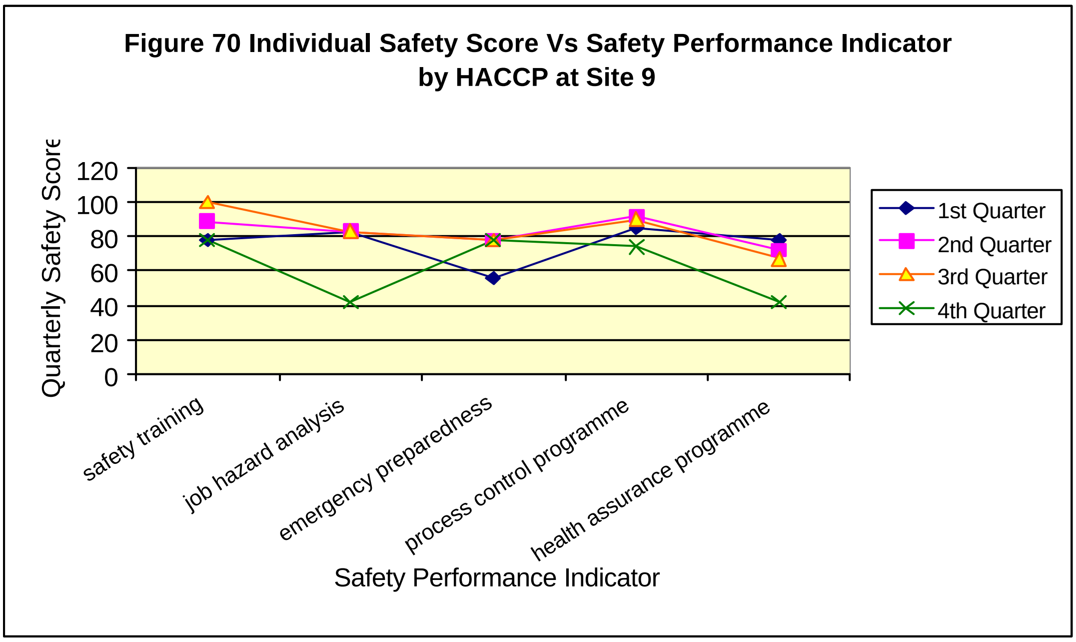

Comment 6: A consistent safety performance trend has been witnessed. 1 out of 5 CPIs (namely process control programme) with score coincidentally at the same level over the past one-year quarterly safety audit indicates little improvement.



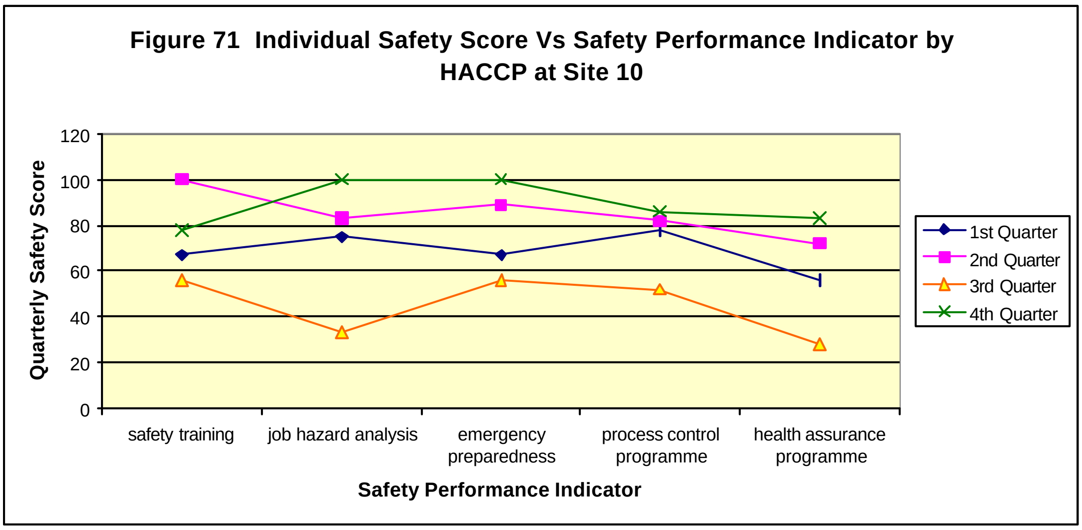

Comment 7: although only 3 quarterly safety audit reports have been collected for studies, improvement in the safety performance is still witnessed over the past one-year quarterly safety audit.




Comment 8: A general trend on the safety performance over the 3 quarterly safety audit is witnessed. 1 out of 5 CPIs (namely emergency preparedness) is obviously maintained at a level where little improvement has been done.

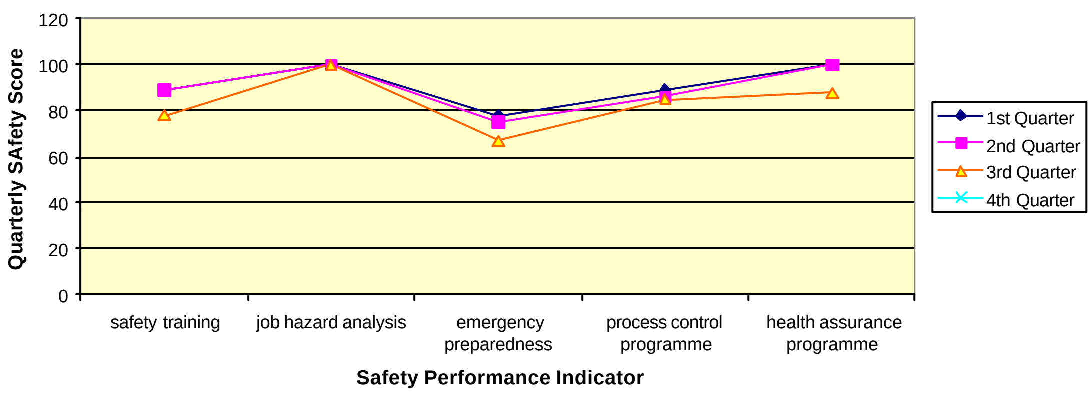



Comment 9:No obvious safety performance trend can be concluded.



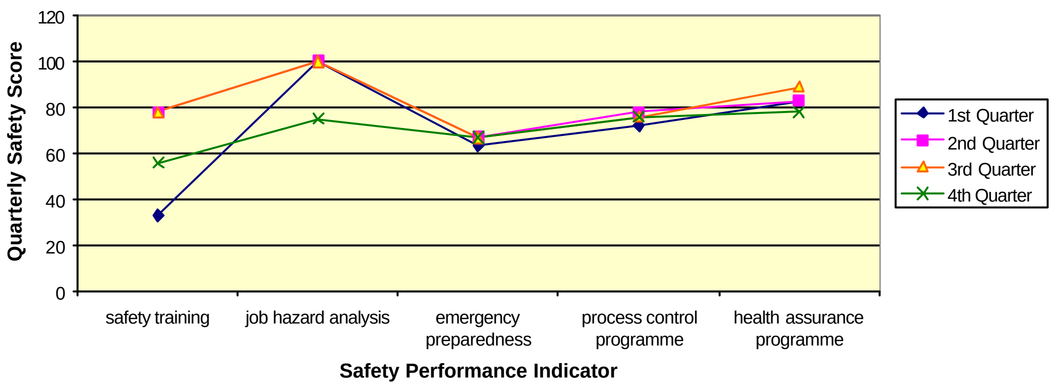

Comment 10: The 5 CPIs identified by HACCP can clearly express the extent of the continuous improvement or progress in safety management over one year period.

**Figure 72 Individual Safety Score Vs Safety Performance Indicator by HACCP at Site 11**




Comment 11:The graphic typically shows the top management's effort and attitude towards safety audit. The five CPIs identified by HACCP steadily maintain at a pattern trend that nearly all these five CPIs kept at the same score level over 3 quarters' safety audit. Very little improvement for these five CPIs is witnessed.

**Figure 73 Individual Safety Score Vs Safety Performance Indicator by HACCP at Site 12**




Comment 12: 3 out of 5 CPIs identified by HACCP maintained at nearly same score level, so that there was little progress in emergency preparedness, process control programme, and health assurance programme.

**OVERALL COMMENT OF USING HACCP TO HELP ISAS INTERPRETE SAFETY PEFORMANCE OF SMS**

It is noticed that 8 out of 12 sites namely site 1 to 6, site 11 and site 12 show little improvement on quarterly safety audit score over one year at respective figure 62 to 67, 72 and 73. Two most obvious indications are found at site 11 and site 12. These findings indicate that there is little improvement in the safety and health management system when looking at the CCPIs identified by the HACCP alone.

Looking at the safety pattern constructed by CCPIs, one can easily tell which safety elements need attention for improvement. This safety pattern helps allocate resources and effort in improvement in safety management system as a review.

**OUTCOME TO ANALYSIS OF RESULT II---IMPROVEMENT OF ISAS BY HACCP**

8 out of 12 construction sites shown in the way of 5 critical control point (CCPIs) identified by HACCP clearly unveil what safety control measures should be impinged on the safety management system for continuous improvement.

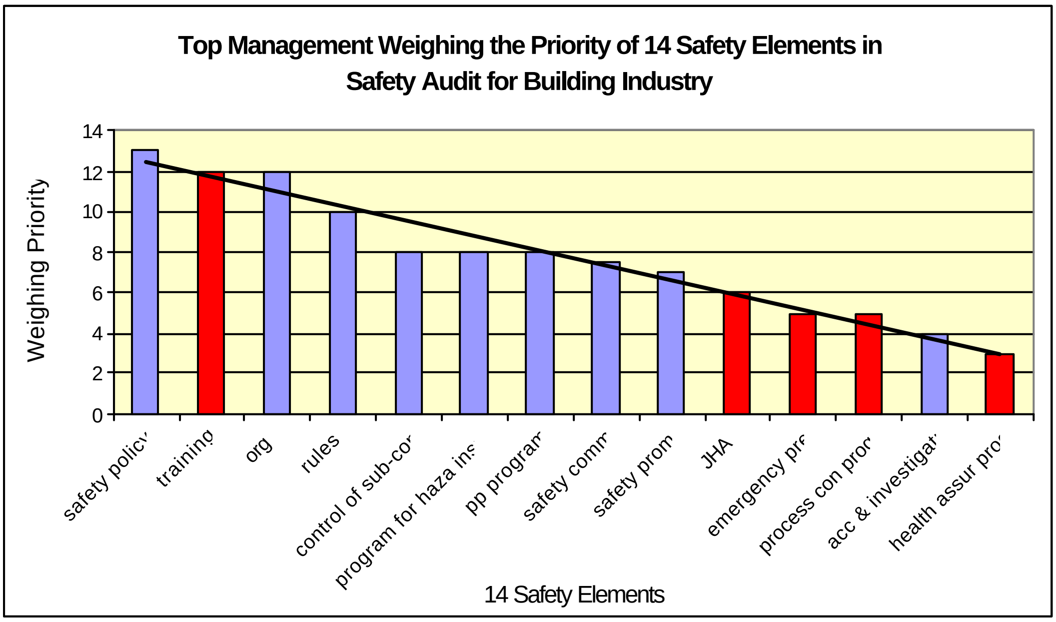
# CHAPTER 10

# ANALYSIS OF RESULT III: EVALUATION ON THE FEASIBILITY OF HACCP TO IMPROVE ISAS

The Hazard Analysis and Critical Control Point (HACCP) process gives an encouraging result in checking the effective implementation and assessing the continuous improvement of safety management system (SMS) through the two-tier performance indicators, namely Control Point Indicator (CPI) and Critical Control Point Indicator (CCPI). Of which the HACCP has classified the 14 safety elements of Independent Safety Audit System (ISAS) into 5 CCPIs and 9 CPIs.

From figure 74, it shows that the top management ranks safety policy as the most important element whereas health assurance programme is ranked as the least important element. Ironically 4 out of 5 safety elements classified as CCPIs by HACCP are ranked as least important in priority by top management when discharging the SMS duties as shown at figure 74. These may explain why the accident rate in the construction industry still ranked top among others as the top management has not yet paid enough attention to these CCPIs. However the safety element of accident and incident investigation has been placed as least priority by top management, but HACCP takes no notice of this element as CCPI. Therefore there is a need to clarify the feasibility of HACCP into ISAS as an improvement measure.

Figure 74 CCPIs and the top management's safety priority trend for 14 safety elements of safety audit for building industry



**VERIFICATION OF TOP MANAGEMENT PREFRENCE TOWARDS 14 SEs**

The test is in 2-stage namely Factor Analysis and Rank Correlation under SPSS. Factor Analysis is used for identification of factor(s) most closely related to the top management's effort and attitude when discharging SMS duties. Rank Correlation as a second stage is to check the most closely related factor(s) identified by Factor Analysis with 14 safety elements. As a result, the findings can verify the successfulness of HACCP classifying the safety elements into CPI or CCPI.

## Stage 1: Factor Analysis

Factor analysis can reduce a large number of variables to a smaller set to be handled which reflects similar or distinct concepts of some measurements (Bryman & Cramer, 1997). In this connection, eight questions are set in the questionnaire representing two types of variables, namely effort and attitude held by top management. These questions or variables are labelled as effort 1, effort 2, effort 3 and effort 4 for respectively question 4, question 5, question 6 and question 7. Whereas variables labelled as attitude 1, attitude 2, attitude 3 and attitude 4 represent respective question 8, question 9, question 10 and question 11. The focus of these variables is to evaluate how effort and attitude affect a construction company when implementing 14 safety elements in the safety audit and are detailed at table 1. All these findings of the questions also variables go through four steps known as correlation matrix, communalities, total variance explained and factor matrix under factor analysis in the Statistical Package for the Social Sciences (SPSS).

Correlation Matrix in Factor Analysis is the initial step to compute a correlation matrix for the eight items. This makes up the two scales of effort and attitude. If there are no significant correlation among these items, then this means that they are unrelated and not worthwhile to go on to conduct a factor analysis. If there are some significant correlations among these items, a number of initial factors are scaled down to a few closely related factors. In essence some meaningful and presentable factors can be analyzed.

**STEP 1: Correlation Matrix**

Table 18 Correlation matrix

| | | effort1 | effort2 | effort3 | effort4 | attitud1 | attitud2 | attitud3 | attitud4 |
|---|---|---|---|---|---|---|---|---|---|
| Correlation | effort1 | 1.000 | .041 | .002 | .166 | .053 | .378 | .142 | .200 |
| | effort2 | .041 | 1.000 | .036 | -.153 | .290 | -.195 | **.405** | .152 |
| | effort3 | .002 | .036 | 1.000 | -.068 | -.205 | .029 | .027 | -.001 |
| | effort4 | .166 | -.153 | -.068 | 1.000 | -.054 | .346 | .090 | .057 |
| | attitud1 | .053 | .290 | -.205 | -.054 | 1.000 | -.063 | .037 | .101 |
| | attitud2 | .378 | -.195 | .029 | .346 | -.063 | 1.000 | .101 | .126 |
| | attitud3 | .142 | **.405** | .027 | .090 | .037 | .101 | 1.000 | .209 |
| | attitud4 | .200 | .152 | -.001 | .057 | .101 | .126 | .209 | 1.000 |
| Sig. (1-tailed) | effort1 | | .341 | .494 | .050 | .299 | .000 | .080 | .023 |
| | effort2 | .341 | | .360 | .064 | .002 | .026 | .000 | .066 |
| | effort3 | .494 | .360 | | .252 | .021 | .389 | .395 | .497 |
| | effort4 | .050 | .064 | .252 | | .296 | .000 | .187 | .286 |
| | attitud1 | .299 | .002 | .021 | .296 | | .267 | .356 | .158 |
| | attitud2 | .000 | .026 | .389 | .000 | .267 | | .159 | .106 |
| | attitud3 | .080 | .000 | .395 | .187 | .356 | .159 | | .018 |
| | attitud4 | .023 | .066 | .497 | .286 | .158 | .106 | .018 | |

In table 18, correlation matrix for these eight items shows their significant level and correlation coefficient. It is noticed that some items are significantly correlated at less than the 0.05 level of significance in pairwise. For example the correlation between item effort2 and attitude3 is 0.405 which is the highest correlation among all these pairs. It is believed that these two variables constitute a major component in the factor identified by the factor analysis.

**STEP 2: Communalities**

For Factor Analysis, Principal Axis Factoring is used. In this aspect, only the variance, common to or shared by the tests is analyzed such as the common or shared parts labelled as A, B, C and D in the figure 75. The variance of a test to be explained is known as its communality. This is an attempt to exclude unique variance of the parts labelled as X, Y and Z from the analysis which is not shared with by any variables.

**Figure 75 Common and unique variance**

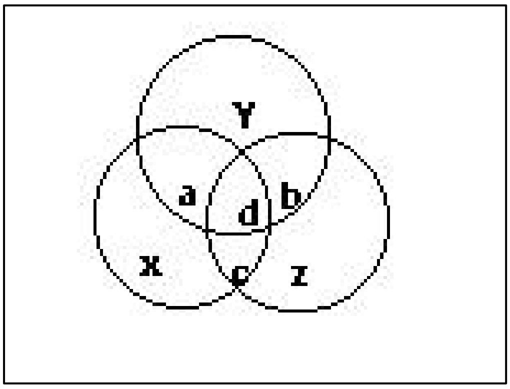



Table 19 Communalities

| | Initial | Extraction |
|---|---|---|
| effort1 | .180 | .267 |
| effort2 | .312 | .711 |
| effort3 | 5.976E-02 | 9.244E-02 |
| effort4 | .146 | .190 |
| attitud1 | .145 | .569 |
| attitud2 | .271 | .593 |
| attitud3 | .231 | .345 |
| attitud4 | 8.832E-02 | .128 |

Extraction Method: Principal Axis Factoring.

From table 19 of communalities, it indicates that the values of the communalities vary from 0.312 (for the second factor) to 5.976x10-2 (for the third factor). It is further indicated that variable of effort2 is somewhat constitute major communalities in factors identified by the Factor Analysis.

**Step 3: Total Variance Explained**

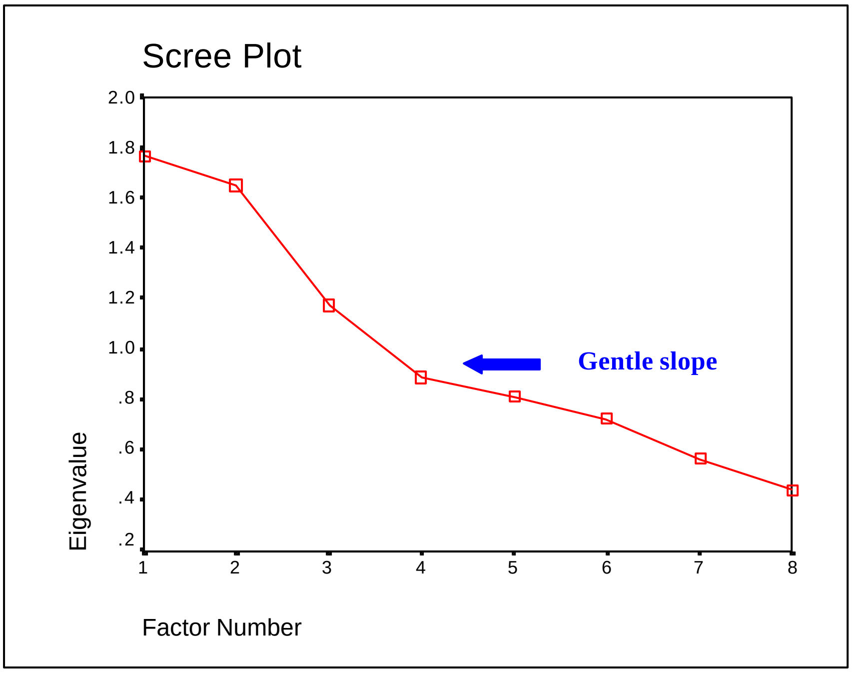
Table 20 Total variance explained

| Factor | Initial Eigenvalues | | | Extraction Sums of Squared Loadings | | | Rotation |
|---|---|---|---|---|---|---|---|
| | Total | % of Variance | Cumulative % | Total | % of Variance | Cumulative % | Total |
| 1 | 1.767 | 22.082 | 22.082 | 1.218 | 15.223 | 15.223 | 1.136 |
| 2 | 1.648 | 20.602 | 42.684 | 1.134 | 14.176 | 29.399 | 1.140 |
| 3 | 1.172 | 14.649 | 57.333 | .545 | 6.810 | 36.209 | .660 |
| 4 | .886 | 11.073 | 68.406 | | | | |
| 5 | .806 | 10.079 | 78.485 | | | | |
| 6 | .720 | 9.003 | 87.488 | | | | |
| 7 | .564 | 7.056 | 94.544 | | | | |
| 8 | .436 | 5.456 | 100.000 | | | | |

Extraction Method: Principal Axis Factoring.
a When factors are correlated, sums of squared loadings cannot be added to obtain a total variance.

In table 20 of Total Variance Explained, 8 factors have been arranged in descending order according to the initial Eigenvalues. These are shown at the column of Total under the Initial Eigenvalues. These Eigenvalues are plotted in Scree Plot graphic as shown in figure 76. The graphical scree test proposed by Cattell (1966) is used to decide how many factors should be kept.

Figure 76 Scree plot



In this study, eight factors representing eight variables are plotted against the Eigenvalues showing the descending variance. The plot typically shows a break between the steep slope and the gentle one.

The factors to be retained are those which lie before the point at which the Eigenvalues seem to level off. This occurs when the Eigenvalues are less than one. In this case the first three factors in with eigenvalues greater than one are retained as most closely related factors for further studies.

**STEP 4: Factor Matrix**

Table 21 Factor Matrix

| | Factor | | |
|---|---|---|---|
| | 1 | 2 | 3 |
| **effort2** | **.812** | **.120** | **.193** |
| **attitude3** | **.372** | **.371** | **.263** |
| attitude2 | -.343 | .688 | -5.382E-02 |
| effort1 | -2.092E-02 | .515 | -3.992E-02 |
| effort4 | -.219 | .373 | -5.334E-02 |
| attitude4 | .174 | .313 | 1.755E-02 |
| attitude1 | .471 | 8.029E-02 | -.583 |
| effort3 | -4.635E-02 | -6.830E-03 | .300 |

Extraction Method: Principal Axis Factoring.

a Attempted to extract 3 factors. More than 25 iterations required. (Convergence=6.328E-03). Extraction was terminated.

From table 21 of Factor Matrix, the items have been listed, by request, in terms of the size of their loadings on the factor to which they are most closely related. The item of **effort 2** representing number of summons have been prosecuted over the past 3 years loads most highly on the first factor as 0.81. Whereas its corresponding value loading in factor 2 as 0.12 and in factor 3 as 0.193 are very low that they are ignored in discussion.

The second closely related variable is the item of **attitude3** representing the accident target rate set in safety policy. This factor loads evenly importance in all three factors with loading values at 0.31, 0.371 and 0.263 respectively.

The rest of these variables will not be considered due to their corresponding low loading value or inconsistent direction of correlation in either factor 1 or 2 or 3. For example the third component of ‘attitude 2’ representing ‘top management attending safety committee meeting’ should have been kept as recommended by the Scree plot at figure 76. However the inconsistent loading values as negative for both factor 1 and 3 as –0.34 and –0.05382 but positive values for factor 2 as 0.688 do not show a convincing argument as the first two factors. In addition the loading value of attitude 2 in factor 3 is just –0.05382 which is too minute to be considered.

As a result only effort 2 rank the most closely related and attitude 3 rank the second are considered as presentable factors. By then they can be used for exploring the relationships between the respective effort and attitude with the 14 safety elements in the ISAS safety audit by RANK CORRELATION.

## STAGE 2: RANK CORRELATION

In order to figure out whether or not the effort and attitude held by top management defined in the questionnaire have some effects on preferential allocation of resource to 14 safety elements, a statistical analytical method namely rank correlation is employed. This type of statistical analytical method has been successfully adopted by Lai (1995) when performing a dissertation study on Safety Management for Construction to test the correlation between various safety management measures and safety performance.

Two most closely related variables, namely number of summons over the past three years and accident target rate set in the safety policy are identified by Factor Analysis. They are then tested with 14 safety elements in ISAS under the method of bivariate correlation analysis.

Due to the level of measurement for the variables including effort and attitude in this case are at ordinal level, one of the prominent and suitable method in the correlation measurement is Spearman's rho of Rank Correlations. Two factors generated from Factor

Analysis are correlated with 14 safety elements used in the ISAS safety audit by computing into the rho in SPSS.  As a result a table of rank correlation showing the correlation in pairwise of each factor is obtained and detailed at table 22.

**Step 1: Rank Correlations**

Table 22 Rank Correlation

| | | | effort2 | attitude3 |
|---|---|---|---|---|
| Spearman's rho | **1. Ranking for safety policy** | Correlation Coefficient | -.008 | **-.193*** |
| | | Sig. (1-tailed) | .469 | .029 |
| | | N | 98 | 97 |
| | 2. Safety organization | Correlation Coefficient | .071 | -.122 |
| | | Sig. (1-tailed) | .243 | .118 |
| | | N | 97 | 96 |
| | **3. Safety training** | Correlation Coefficient | **.190*** | .290** |
| | | Sig. (1-tailed) | .031 | .002 |
| | | N | 97 | 96 |
| | 4. In-house safety rules and regulations | Correlation Coefficient | -.032 | .129 |
| | | Sig. (1-tailed) | .376 | .105 |
| | | N | 97 | 96 |
| | 5. Programme for inspection of hazardous condition | Correlation Coefficient | -.038 | -.142 |
| | | Sig. (1-tailed) | .355 | .084 |
| | | N | 97 | 96 |
| | 6. Personal protection programme | Correlation Coefficient | .040 | .141 |
| | | Sig. (1-tailed) | .351 | .087 |
| | | N | 96 | 95 |
| | **7. Accident & incident investigation** | Correlation Coefficient | -.017 | **-.171*** |
| | | Sig. (1-tailed) | .434 | .048 |
| | | N | 96 | 95 |
| | 8. Emergency preparedness | Correlation Coefficient | -.056 | -.056 |
| | | Sig. (1-tailed) | .293 | .294 |
| | | N | 97 | 96 |
| | 9. Safety committee | Correlation Coefficient | .051 | -.045 |
| | | Sig. (1-tailed) | .310 | .331 |
| | | N | 97 | 96 |
| | 10. Evaluation, selection & control of sub-contractor | Correlation Coefficient | -.091 | .013 |
| | | Sig. (1-tailed) | .189 | .450 |
| | | N | 97 | 96 |
| | 11. Job hazard analysis | Correlation Coefficient | -.035 | .047 |
| | | Sig. (1-tailed) | .368 | .325 |
| | | N | 96 | 95 |
| | 12. Safety promotion | Correlation Coefficient | .050 | .096 |
| | | Sig. (1-tailed) | .313 | .174 |
| | | N | 98 | 97 |
| | **13. Process control programme** | Correlation Coefficient | **-.176*** | -.155 |
| | | Sig. (1-tailed) | .042 | .066 |
| | | N | 97 | 96 |
| | 14. Health assurance programme | Correlation Coefficient | .068 | -.025 |
| | | Sig. (1-tailed) | .255 | .403 |
| | | N | 96 | 95 |

*** Correlation is significant at the .05 level (1-tailed).**

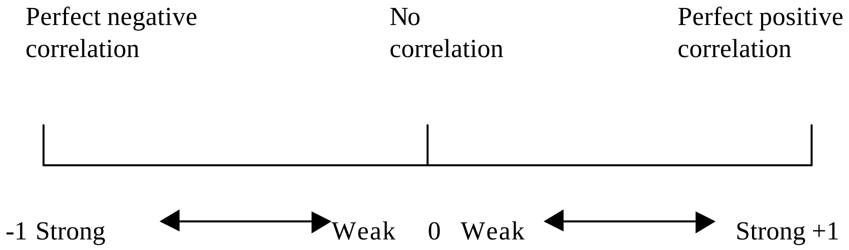
**** Correlation is significant at the .01 level (1-tailed).**

From table 22, two most closely related variables, namely effort 2 and attitude 3 identified from Factor Analysis are put in two separate columns and the 14 safety elements are put in individual rows. Each variable is correlated with each of 14 safety elements by indicating the correlation coefficient, significant level (1-tailed) and number of sample size.

As for the correlation coefficient, its interpretation can be referred as follows. When the coefficient is at the value of 0.19 and below, its correlation is very low. When the coefficient is at 0.2 to 0.39, its corresponding correlation is low. Whereas the coefficient at the value of 0.40 to 0.69 has a modest correlation. Progressively when the coefficient is at the value of 0.70 to 0.89, its correlation is high. Finally, when the coefficient is at 0.90 to 1, the correlation is very high. However these are rules-of-thumb and should not be regarded as definitive indicatives, since there are hardly any guidelines for interpretation over which there is substantial consensus (Cohen & Holliday, 1982).

The relative strength and direction of correlation can conclusively be explained by the following scale:

Figure 77 The strength and direction of correlation coefficients




Furthermore, the indication of asterisk (*) and (**) with correlation coefficient in the row of the table 22 of rank correlation refers to the statistical significance at respective $p<0.05$ and $p<0.01$. This study is designed to focus the statistical significance at $p<0.05$ with the indication of asterisk (*).

## Step 2: Interpretation of Rank Correlations

### CORRELATION OF THE FIRST FACTOR WITH 14 SAFETY ELEMENTS

The **first factor** from Factor Analysis---effort 2 referring to the **number of summons having been prosecuted over the past three years** is correlated with 14 safety elements from ISAS safety audit.

Under the rank correlation analysis at step 1, only two safety elements out of 14 are found significantly correlated with the first factor at the level of $p<0.05$ as shown in table 23. They are safety training and process control programme with correlation coefficients at respective 0.19 and –0.176. These two values of correlation coefficients 0.19 and –0.176 in these rank correlations are regarded as very low but significant with $p<0.05$ in the sample size of 97 participants.

**Table 23 14 safety elements' ordering according to the correlation with first factor---effort2**

| Ordering | Correlation coefficient |
|---|---|
| Safety training | .190* |
| Process control programme | -.176* |
| Safety organization | 0.071 |
| Health assurance programme | 0.068 |
| Safety committee | 0.051 |
| Safety promotion | 0.05 |
| Personal protection programme | 0.04 |
| Safety policy | -0.008 |
| Accident & incident investigation | -0.017 |
| In-house safety rules & regulations | -0.032 |
| Job hazard analysis | -0.035 |
| Program for inspection of hazardous condition | -0.038 |
| Emergency preparedness | -0.056 |
| Evaluation, selection & control of sub-contractor | -0.091 |

This means that the building contractors who put good effort into maintaining a good summons record also put good safety training input. However, the building contractors do not allocate corresponding effort or resources in the process control programme.

**CORRELATION OF THE SECOND FACTOR WITH 14 SAFETY ELEMENTS**

The **second factor** from Factor Analysis---attitude 3 referring to the **accident target rate set in the safety policy** is correlated with 14 safety elements from ISAS safety audit.

Under the rank correlation analysis at step 1, only two safety elements out of 14 are found significantly correlated with the second factor at the level of $p<0.05$ as shown in table 24. They are safety policy and accident and incident investigation with correlation coefficients at respective –0.193 and –0.171. These two values of correlation coefficients -0.193 and -0.171 in the rank correlation analysis are regarded as very low but significant in the sample size of around 97 participants.

This means that a positive attitude shared by the building contractors in maintaining a high standard of accident target rate (e.g. zero rate) will treat both safety policy at workplace and accident & incident investigation as unimportant in the safety priority trend as viewed by top management.

| Table 24 14 safety elements' ordering according to the correlation with second factor---attitude3 | |
|---|---|
| **Ordering** | **Correlation coefficient** |
| Safety policy | -.193* |
| Safety training | .290** |
| Accident & incident investigation | -.171* |
| Personal protection programme | 0.141 |
| In-house safety rules & regulations | 0.129 |
| Safety promotion | 0.096 |
| Job hazard analysis | 0.047 |
| Evaluation, selection & control of sub-contractor | 0.013 |
| Health assurance programme | -0.025 |
| Safety committee | -0.045 |
| Emergency preparedness | -0.056 |
| Safety organization | -0.122 |
| Programme for inspection of hazardous condition | -0.142 |
| Process Control programme | -0.155 |

## CONCLUSION TO THE ANALYSIS OF RESULT III

The top management's effort and attitude has somehow affected the implementation of 14 safety elements with various level of significant and correlation coefficient as tested by Factor Analysis and Rank Correlation of SPSS. The four safety elements, namely safety training, process control programme, safety policy and accident & incident investigation are found significantly in either positively or negatively correlated with top management's effort and attitude with the level of significance less than 0.05. The findings are summed up at table 25.

Table 25 Summary of findings of effort and attitude affecting 14 safety elements

| Variables | | | Factor analysis ( ) in descending order of importance | Rank correlation with 14 *safety elements* of ISAS under sig. (1-tailed & p<0.05) |
|---|---|---|---|---|
| **Effort** | **Effort 1** | Q4 contract sum spent on safety. | | |
| | **Effort 2** | Q5 No. of summons having been prosecuted over the past 3 years | **Effort 2 (1st ranking)** | +ve *safety training* |
| | | | | -ve *process control programme* |
| | **Effort 3** | Q6 No. of site being looked after by SO | | |
| | **Effort 4** | Q7 Top management sponsor staff to attend safety training | | |
| | | | | |
| **Attitude** | **Attitude 1** | Q8 94% Top management staff participate the survey | | |
| | **Attitude 2** | Q9 Top management attending safety meeting | | |
| | **Attitude 3** | Q10 Accident target rate set in the safety policy | **Attitude 3 (2nd ranking)** | -ve *safety policy* |
| | | | | -ve *accident & incident investigation* |
| | **Attitude 4** | Q11 Top management taken pro-active either or post-active safety action | | |

# CHAPTER 11

# CONCLUSION

25 per cent of the top management of building industry in Hong Kong responding to this research reveal that they have their own safety priority trends when implementing 14 safety elements of their proprietary safety management system (SMS). The mandatory safety audit similar to Independent Safety Audit Scheme (ISAS) with equal standpoint to judge only the average score of 14 safety elements lead to hide the problem areas of SMS. By virtue of it the mandatory safety audit cannot truly tell how effective the SMS is and what extent the continuous improvement has been made for SMS. Therefore the null hypothesis $H_0 1$ referring to a statement of 'there is no significant correlation when comparing the score of 14 individual safety elements of the ISAS that can provide consistent and useful information to ensure continuous improvement in the safety management system' is disproved.

Four safety elements namely safety training, safety policy, accident & incident investigation and process control programme are found significantly correlated with top management's effort and attitude at the significant level less than 0.05. The statement of null hypothesis $H_0 2$ regarding as 'there is no significant correlation among the attitude and effort held by the top management of building contractors and the 14 safety elements of ISAS when discharging their corresponding mandatory safety and health duties' is proved to be false. This explains how top management affects the effectiveness and efficiency of safety elements in ISAS as performance for their safety management system.

Hazard Analysis and Critical Control Point (HACCP) process gives encouraging results to improve the judging process of the ISAS through multi-case studies at 12 construction sites in Hong Kong. HACCP can classify the 14 safety elements of ISAS to form two-tier performance indicators namely Control Point Indicator (CPI) assessing the effective implementation of SMS and Critical Control Point Indicator (CCPI) measuring the continuous improvement of SMS. When using these CPIs and CCPIs to interpret the effectiveness of SMS and identification of weaknesses of SMS for contiguous improvement, a clear picture on the interpretation of the safety performance can be demonstrated at 8 out of 12 construction sites voluntarily participating in this study. Thus, for this study, the statement of null hypothesis $H_0$3 quoting as ‘there is no significant correlation if 14 safety elements are grouped into performance indicators by HACCP’ cannot be true. Therefore there is confidence to say that the two-tier performance indicators of HACCP integrated into ISAS can better unveil the actual safety performance of the SMS.

# CHAPTER 12

# RECOMMENDATIONS

Due to the integration of SMS into a statutory general duty with self-regulatory approach, the top management effort and attitude affect the effective implementation of safety elements for SMS. In essence the weakness of SMS is not easily tracked down after the safety score of all 14 safety elements are averaged at equal weighing factor by mandatory safety audit similar to current ISAS.

For improvement, the current Independent Safety Audit Scheme (ISAS) with 14 safety elements should be classified into two-tier performance indicators by the method of Hazard Analysis and Critical Control Point (HACCP). Of which the Control Point Indicator (CPI) measures the effective implementation of safety management system, which is a prerequisite requirement for safety management system (SMS) before looking for continuous improvement. Afterwards, the Critical Control Point Indicator (CCPI) can assess the continuous improvement for the safety management system.

The judging of safety performance of a SMS is therefore at 2 phases---checking on CPIs and then looking at CCPIs. The particular problem areas for either effective implementation of safety management system or continuous improvement can eventually be dug out for correction.

The integration of HACCP into ISAS for improvement on assessing safety performance of SMS seems to be worked out smoothly in this study. However, the study subjects dominated in this study are the building contractors with the contract sizes of both 0.8 billion representing 30.4% and less than 0.2 billion representing 36.3%. Therefore the application of HACCP into ISAS assessing the SMS of the building contractors would be successful when there are similar contract sizes.

Although there is a whole coverage of the population size referring to building contractors registered under Buildings Department at the Gazette Notice 152 of 1999, only 103 out of 420 respondents replied to the questionnaire-survey. The integration of HACCP into ISAS may not be perfectly applied to those companies that have not taken part into this study. Therefore to ensure an absolute workability of two-tier performance indicators (CPI and CCPI) in assessing the safety performance of SMS, the full cooperation of all these 420 building companies should be sought to try this method. Until then there is confidence to say that the ISAS could really be improved by HACCP. Further study on this aspect is worth while considering.

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**APPENDIX I**

20 July 2000

Dear Respondents,

**SAFETY PERFORMANCE SURVEY**

You are cordially requested to answer the questions which help the researcher evaluate the real life situation at workplace on one hand and improve the mandatory safety audit on the other. As for your voluntary and generous help, it will be most appreciated.

2. As regards the protection of the data provided by each of respondents as listed at the Register of General Building Contractors, they can access to and correct his/her own information whereas any other parties are not allowed to use the data in this survey. The data will be kept as long as the research is completed at the end of December 2000. In all the data supplied by the respondents to this survey will be protected under the Personal Data (Privacy) Ordinance, Cap. 486.

3. In a bid to analyse the result, grateful if you would return the stamped questionnaire by post or fax by **15 August 2000**. Should you have any queries, please feel free to contact me at 2595 8273 (off) or mobile 9257 7032 or e-mail at kcfung@vtc.edu.hk.

Regards,

Cecilia K.C. Fung
Lecturer
Department of Applied Science
Hong Kong Institute of Vocational Education (Chai Wan)

**BY FAX OR POST**

| | | | |
|---|---|---|---|
| From: | The respondent | To: | Cecilia K.C. Fung |
| | | Fax no: | 2505 9747 |
| | | Total no. of page: | 4 |

**QUESTIONNAIRE**

This questionnaire is designed to find out a few things about your building company. Please answer the questions truthfully. There are no right or wrong answers. Please provide a tick (✓) at the appropriate space.

| | | code |
|---|---|---|
| 1. | Nature of building work | |
| ________ | Main contractor | 1 |
| ________ | Sub-contractor | 2 |
| ________ | Joint-venture | 3 |

| | | code |
|---|---|---|
| 2. | Have you got a safety policy at workplace? | |
| ________ | Yes | 1 |
| ________ | No | 2 |

| | | code |
|---|---|---|
| 3. | Over the past three years, the normal contract value bid by your company is around | |
| ________ | 0.8 billion or more | 1 |
| ________ | 0.6 to less than 0.8 billion | 2 |
| ________ | 0.4 to less than 0.6 billion | 3 |
| ________ | 0.2 to less than 0.4 billion | 4 |
| ________ | Less than 0.2 billion | 5 |

| | | code |
|---|---|---|
| 4. | How much of the contract sum will be spent on Health and Safety at workplace such as purchasing of PPE, training programme, promotion, employment of safety personnel and etc.? | |
| ________ | More than 2% | 1 |
| ________ | 1% to less than 2% | 2 |
| ________ | 0.5% to less than 1.0% | 3 |
| ________ | 0.25% to less than 0.5% | 4 |
| ________ | Below 0.25% | 5 |

| | | |
|---|---|---|
| 5. | Have your building company ever been prosecuted over the past three years under Factories and Industrial Undertakings Ordinance, Occupational Safety and Health Ordinance and their subsidiary legislation? | code |
| ________ | Never | 1 |
| ________ | One to five | 2 |
| ________ | Six to ten | 3 |
| ________ | Eleven to fifteen | 4 |
| ________ | More than fifteen | 5 |

| | | |
|---|---|---|
| 6. | As part of the involvement in safety, the top management will (you may tick more than one) | code |
| ________ | Formulate incentive scheme to encourage staff and sub-contractor to observe safety | 1 |
| ________ | Chair/attend company's safety committee | 2 |
| ________ | Inspect site safety | 3 |
| ________ | Give speech to staff about safety | 4 |
| ________ | Study and comment safety statistics | 5 |

| | | |
|---|---|---|
| 7. | How many sites the safety officer shall be responsible for at the same time? | code |
| ________ | One | 1 |
| ________ | Two | 2 |
| ________ | Three | 3 |
| ________ | Four | 4 |
| ________ | Five or more | 5 |

| | | |
|---|---|---|
| 8. | How much you will sponsor your staff to attend safety training course to enhance their safety and health knowledge | code |
| ________ | 100% sponsorship | 1 |
| ________ | >80%, but <100% | 2 |
| ________ | >50%, but <80% | 3 |
| ________ | > 20%, but <50% | 4 |
| ________ | Zero sponsorship | 5 |

| | | |
|---|---|---|
| 9. | What is your current post when filling in this questionnaire? | code |
| ________ | Director | 1 |
| ________ | Chief Executive Officer | 2 |
| ________ | Project Management | 3 |
| ________ | Safety Officer | 4 |
| ________ | Safety Supervisor | 5 |

| | | | |
|---|---|---|---|
| 10. | How often the top management such as Director, Project management and Chief Executive Officer will attend the safety meeting? | code |
| ________ | Every time | 1 |
| ________ | Once every 2 times | 2 |
| ________ | Once every 4 times | 3 |
| ________ | Ad hoc | 4 |
| ________ | Never | 5 |

| | | |
|---|---|---|
| 11. | What is your target of safety performance in terms of accident rate set in the safety policy? | code |
| ________ | Zero | 1 |
| ________ | Annual average accident rate of Hong Kong as reported by Labour Department | 2 |
| ________ | Below the annual average accident rate of Hong Kong | 3 |
| ________ | Comparable to previous record of this own building site | 4 |
| ________ | Below the previous accident rate of the building site | 5 |

| | | |
|---|---|---|
| 12. | At which situation will be deployed with the most effort in achieving good or acceptable safety performance? | code |
| ________ | routine | 1 |
| ________ | After safety inspection | 2 |
| ________ | Prior to safety audit | 3 |
| ________ | After accident | 4 |
| ________ | After prosecution | 5 |

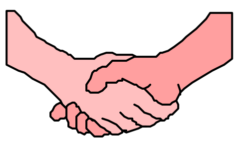
(To objectively get the weighing factor on each of 14 safety elements from the viewpoint of top management of the developers disregarded their own actual effort or attitude)

13. Please prioritize the importance of safety element contributing improving site safety? Please put the nos. 1 – 14 into the space provided that 1 indicates the most importance and 14 as the least importance.

| | | code |
|---|---|---|
| ________ | Safety policy | 1 |
| ________ | Safety organization | 2 |
| ________ | Safety training | 3 |
| ________ | In-house safety rules and regulation | 4 |
| ________ | Programme for inspection of hazardous condition | 5 |
| ________ | Personal protection programme | 6 |
| ________ | Accident/investigation | 7 |
| ________ | Emergency preparedness | 8 |
| ________ | Safety committee | 9 |
| ________ | Evaluation, selection & control of sub-contractor | 10 |
| ________ | Job hazard analysis | 11 |
| ________ | Safety promotion | 12 |
| ________ | Process control programme | 13 |
| ________ | Health assurance programme | 14 |

# End of questionnaire

# THANK YOU



## Priority Trend of 1st Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

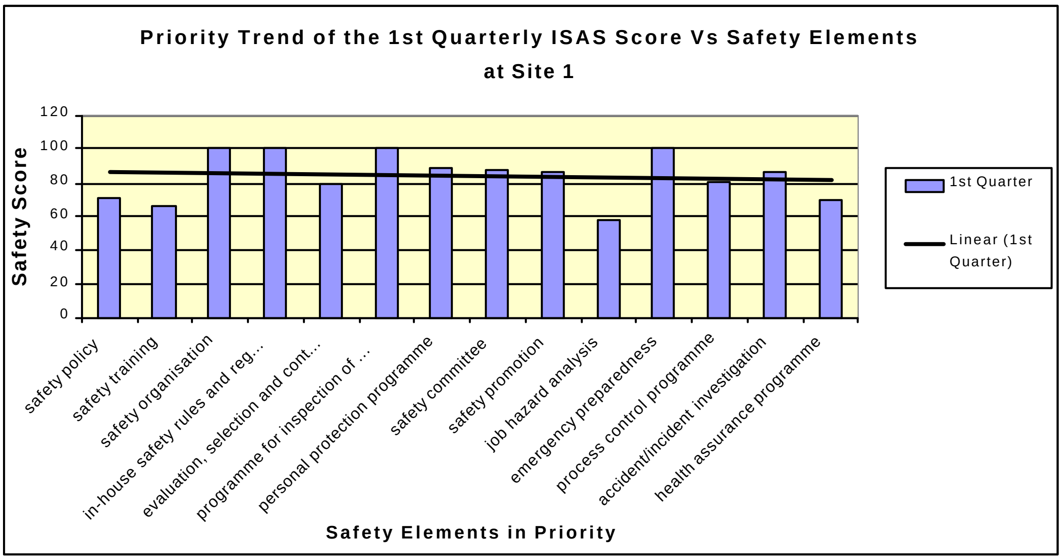



**Figure 17** The 1st-quarterly ISAS at Site 1 complies with the priority trend.

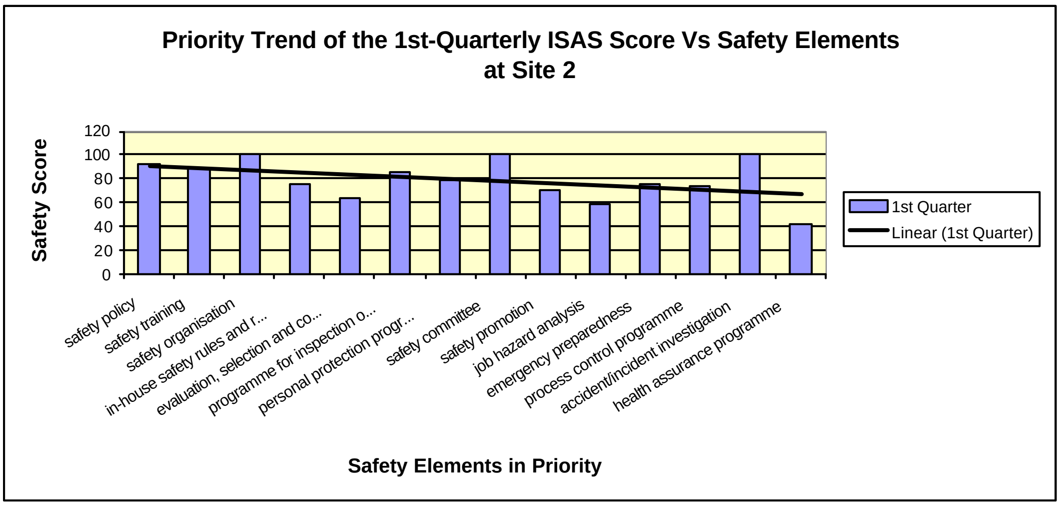
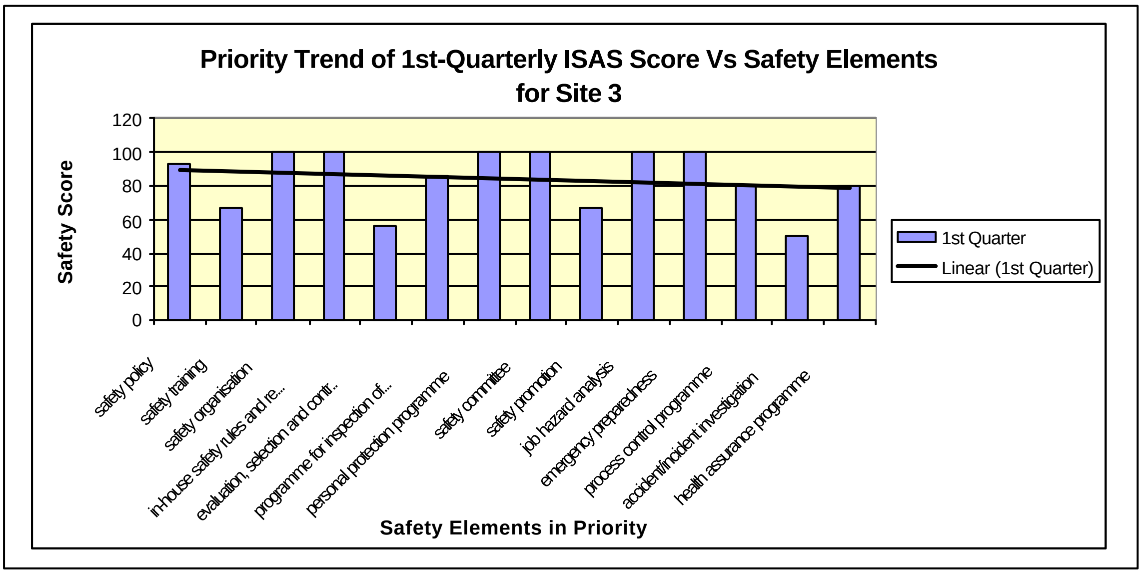
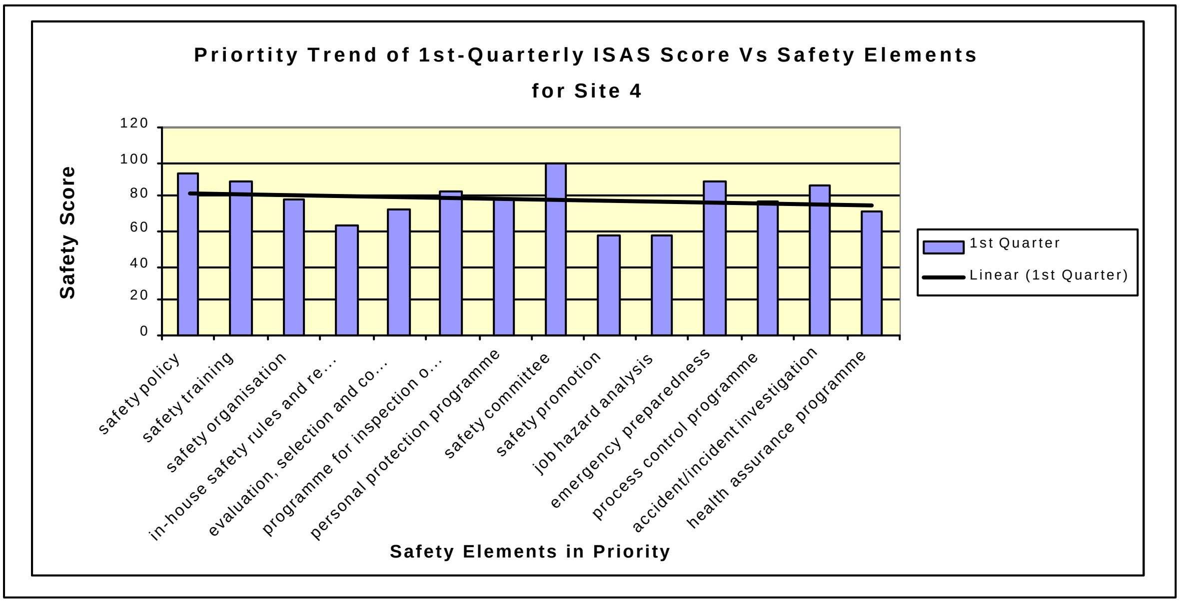



**Figure 18** The 1st-quarterly ISAS at Site 2 complies with the priority trend

**Priority Trend of 1st Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

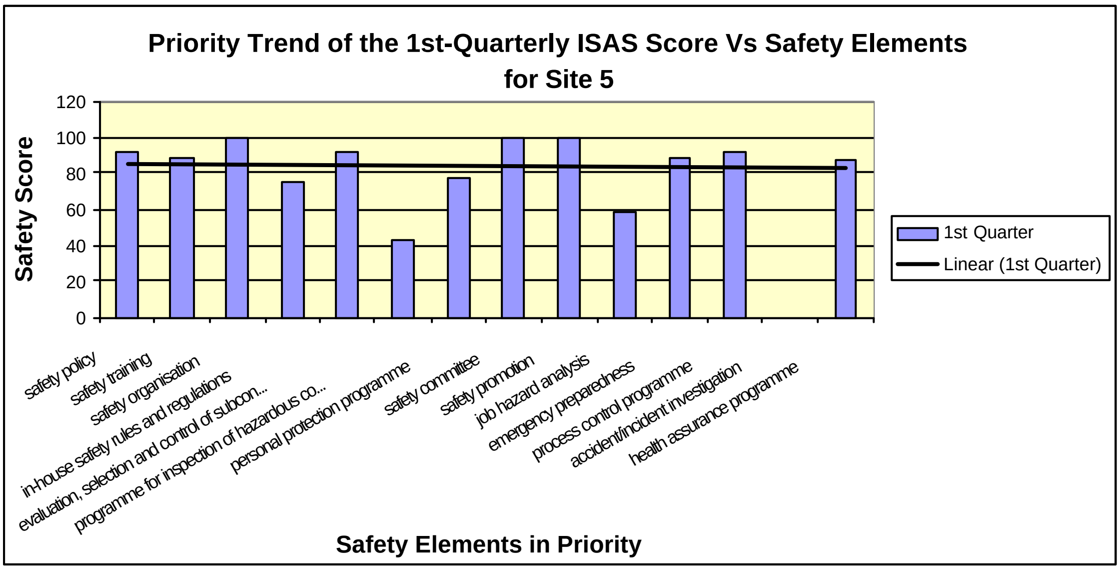



| **Figure 19** | The 1st-quarterly ISAS at Site 3 complies with the priority trend |
|---|---|

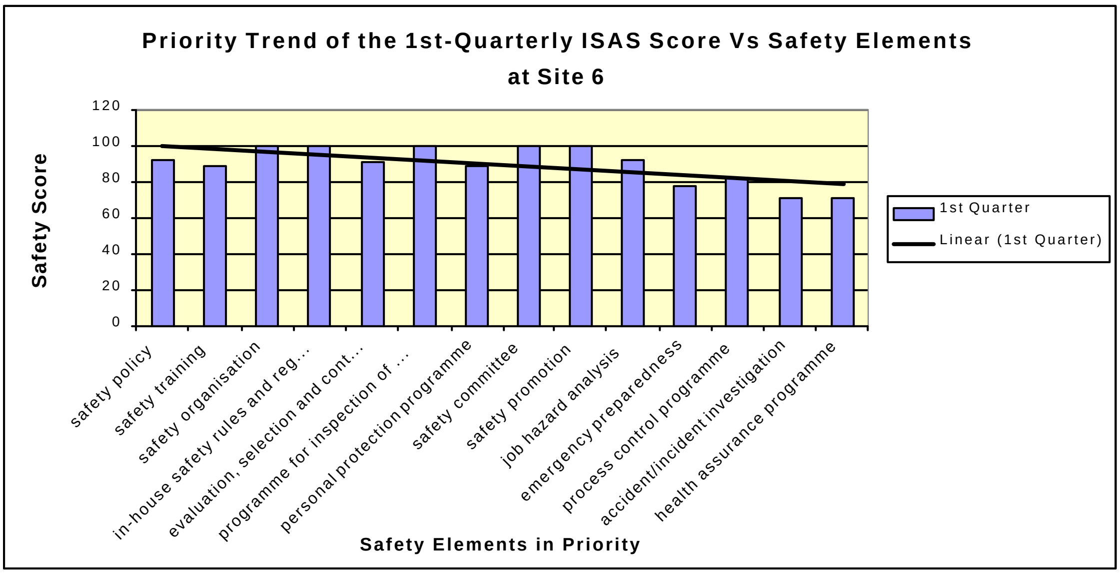



| **Figure 20** | The 1st-quarterly ISAS at Site 4 complies with the priority trend |
|---|---|

**Priority Trend of 1st Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**




| **Figure 21** | The 1st-quarterly ISAS at Site 5 follows the priority trend |
|---|---|




| **Figure 22** | The 1st-quarterly ISAS at Site 6 complies with the priority trend. |
|---|---|

## Priority Trend of 1st Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

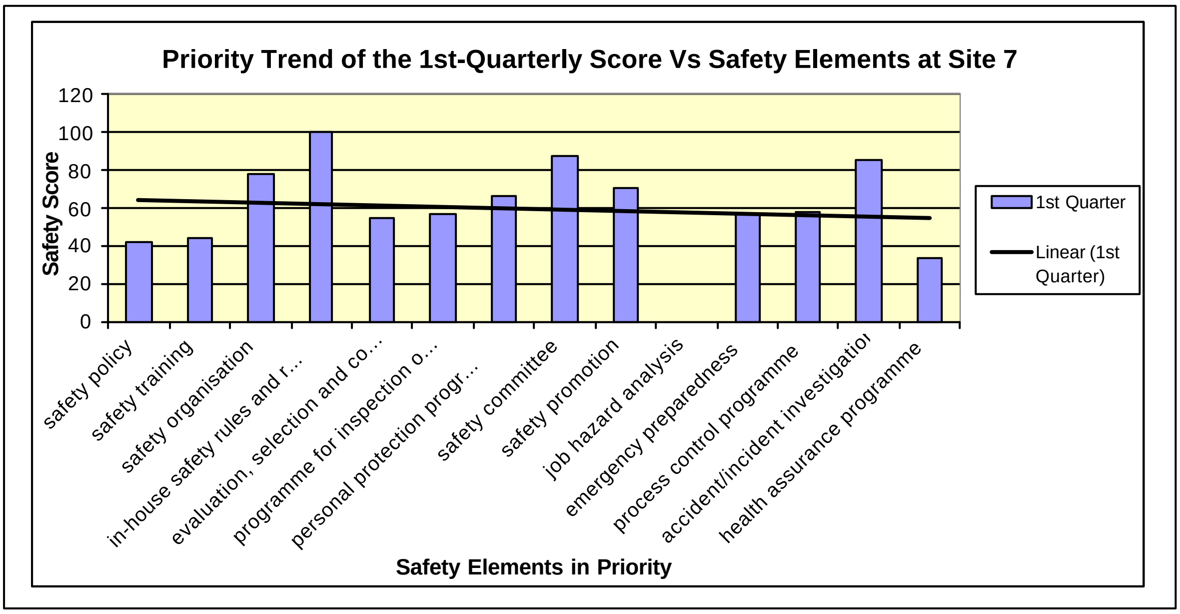



**Figure 23** The 1st-quarterly ISAS at Site 7 complies with the priority trend

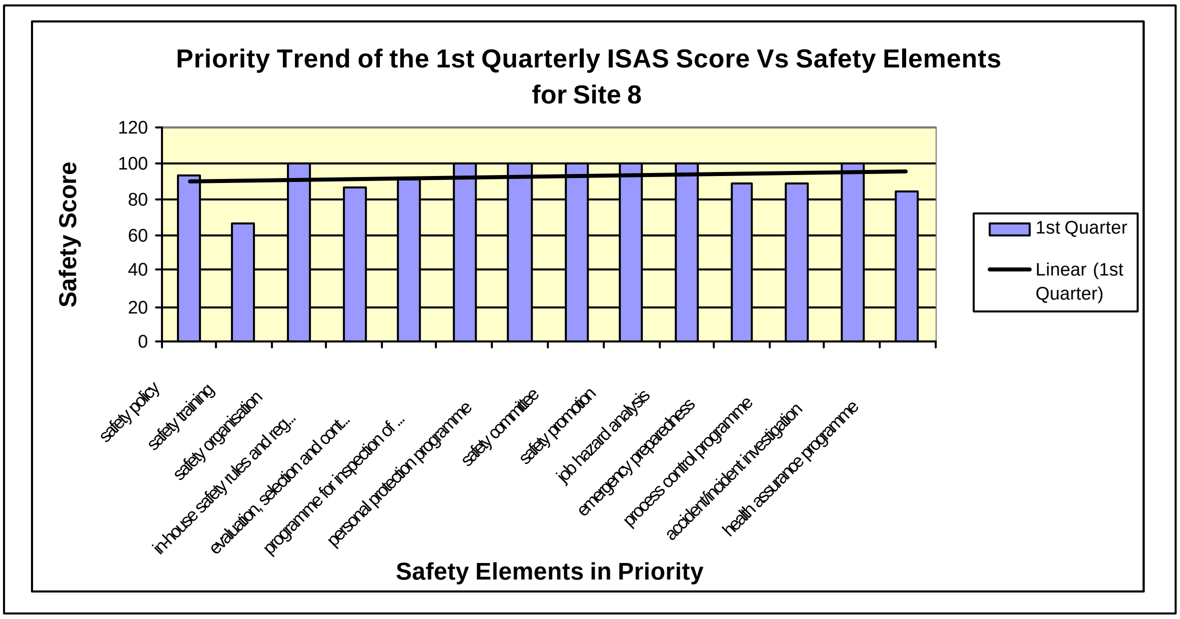



**Figure 24** The 1st-quarterly ISAS at Site 8 **does not** comply with the priority tend

## Priority Trend of 1st Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

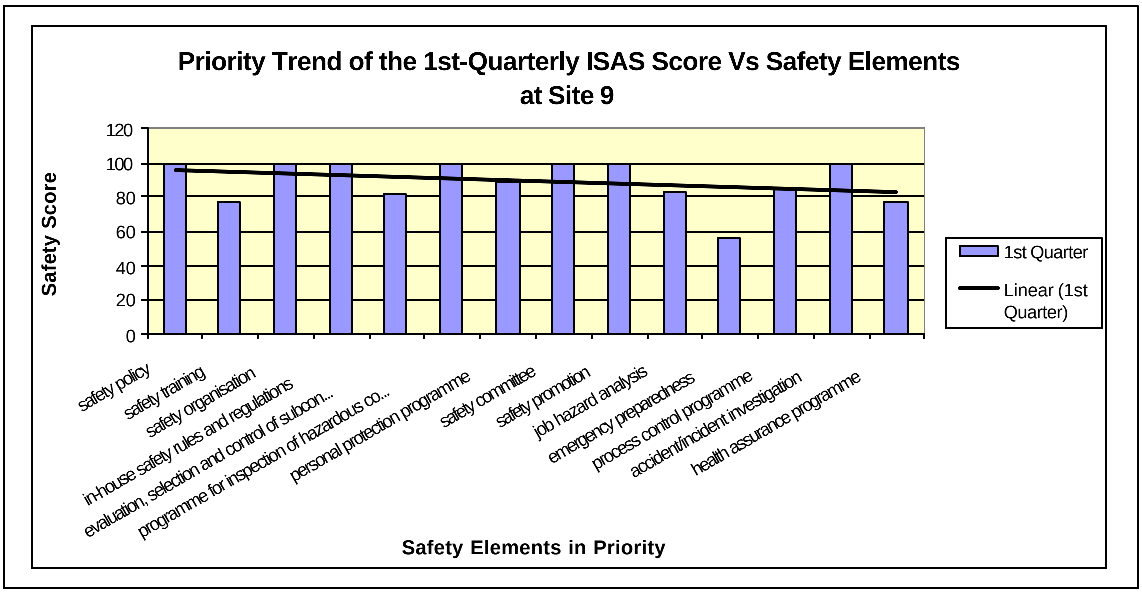



**Figure 25** The 1st-quarterly ISAS at Site 9 complies with the priority trend.

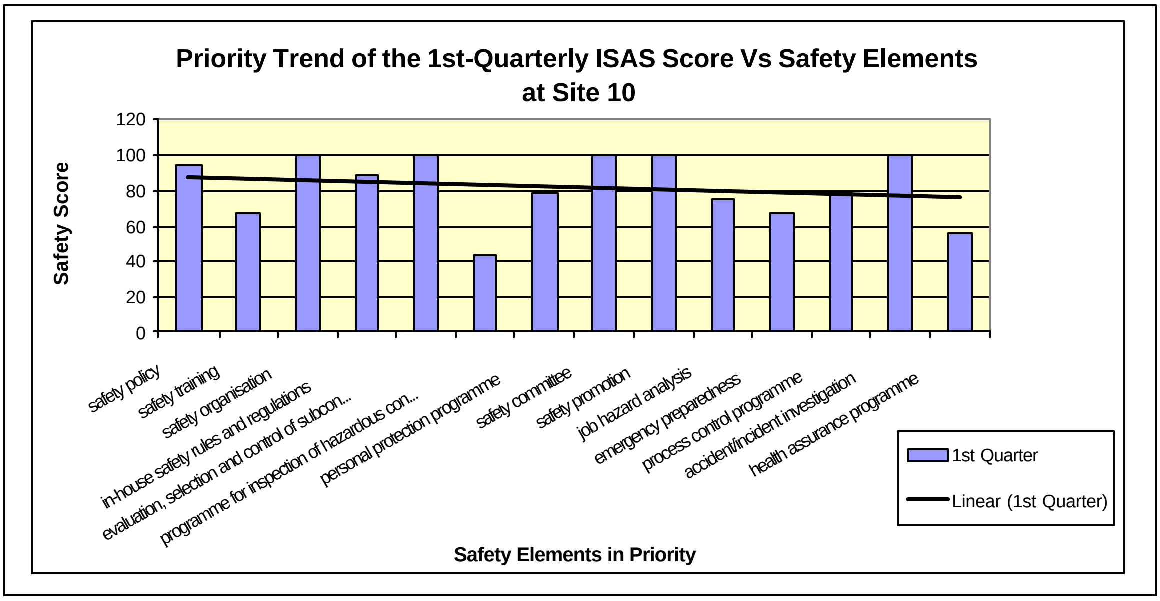



**Figure 26** The 1st-quarterly ISAS at Site 10 complies with the priority trend.

**Priority Trend of 1st Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

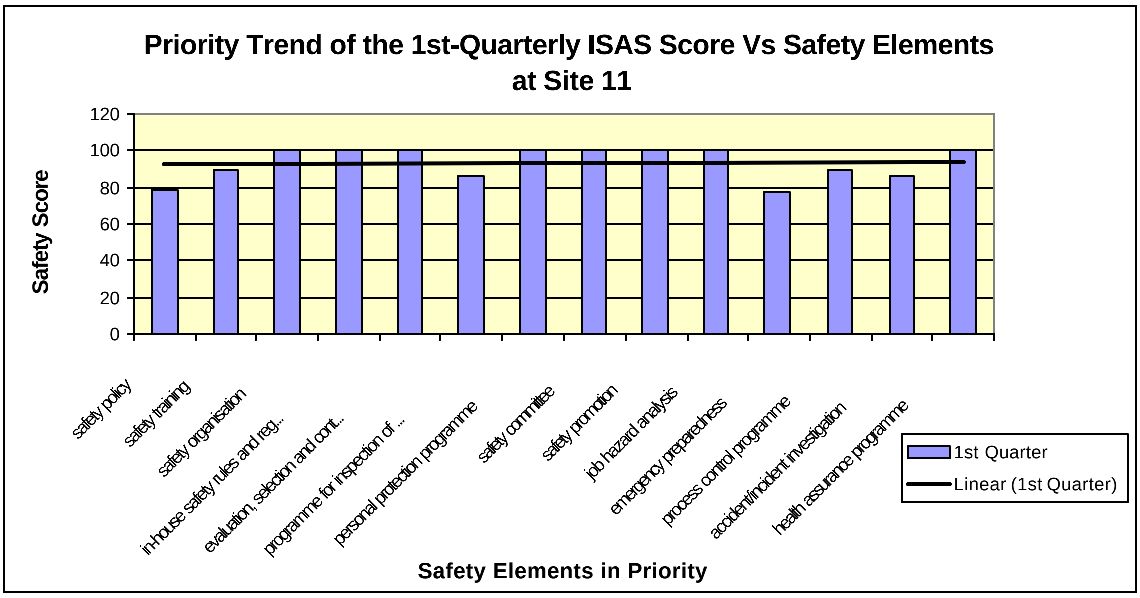



**Figure 27** The 1st-quarterly ISAS at Site 11 **shows no directional** priority trend

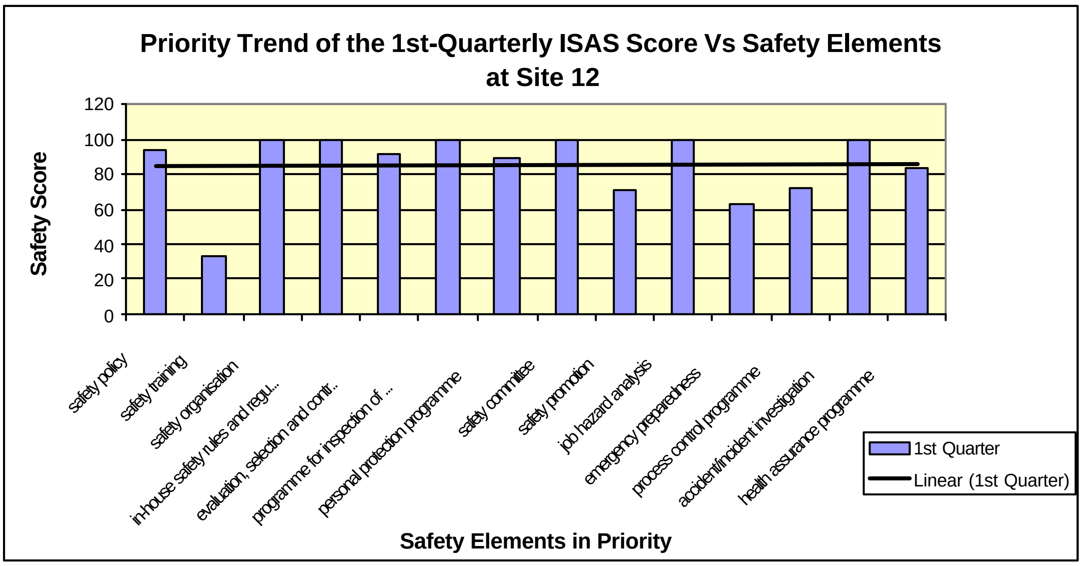



**Figure 28** The 1st-quarterly ISAS at Site 12 **shows no directional** priority trend.

## Priority Trend of 2nd-quarterly ISAS Score Vs Safety Elements at 12 Sites Areas

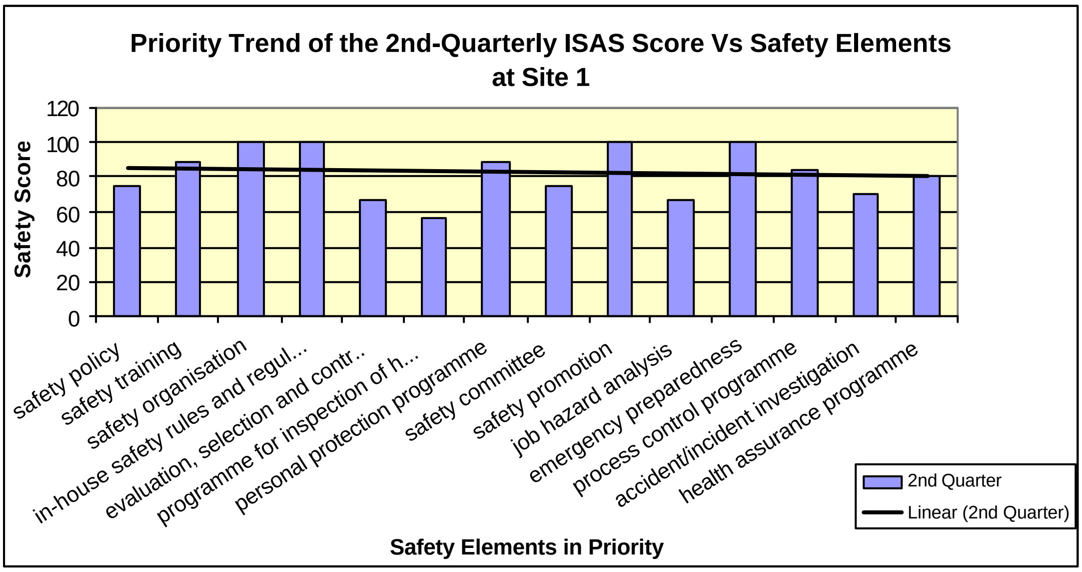



**Figure 29** The 2nd-quarterly ISAS at Site 1 complies with the priority trend.

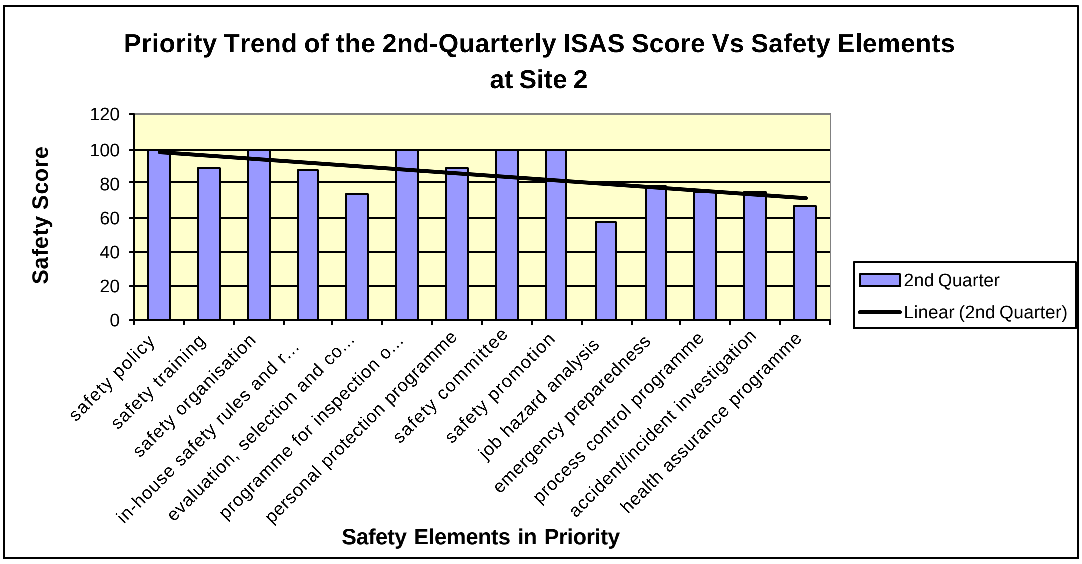



**Figure 30** The 2nd-quarterly ISAS at Site 2 complies with the priority trend.

**Priority Trend of 2nd-quarterly ISAS Score Vs Safety Elements at 12 Sites Areas**

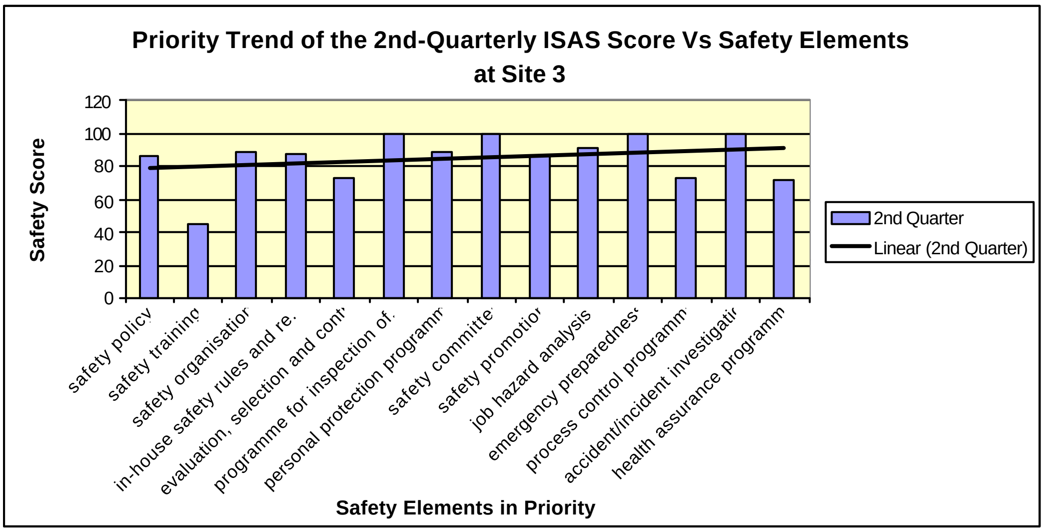



**Figure 31** The 2nd-quarterly ISAS at Site 3 **does not** comply with the priority

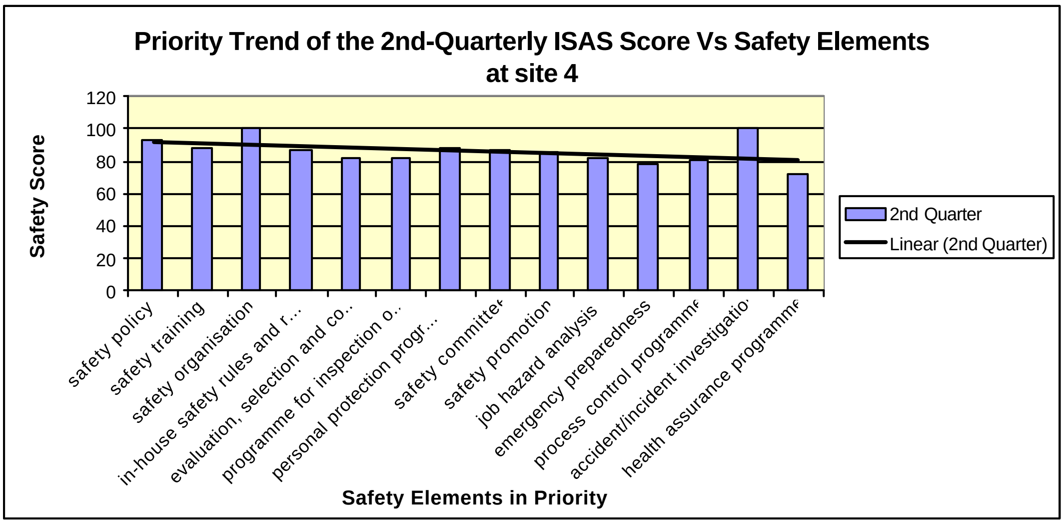



**Figure 32** The 2nd-quarterly ISAS at Site 4 complies with the priority trend.

## Priority Trend of 2nd-quarterly ISAS Score Vs Safety Elements at 12 Sites Areas

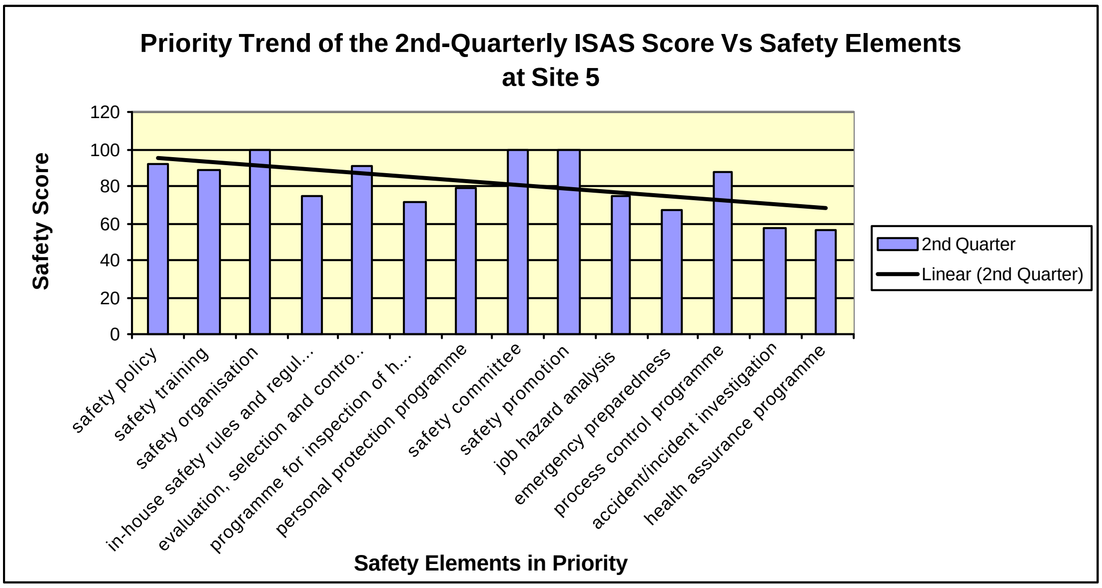



**Figure 33** The 2nd-quarterly ISAS at Site 5 complies with the priority trend.

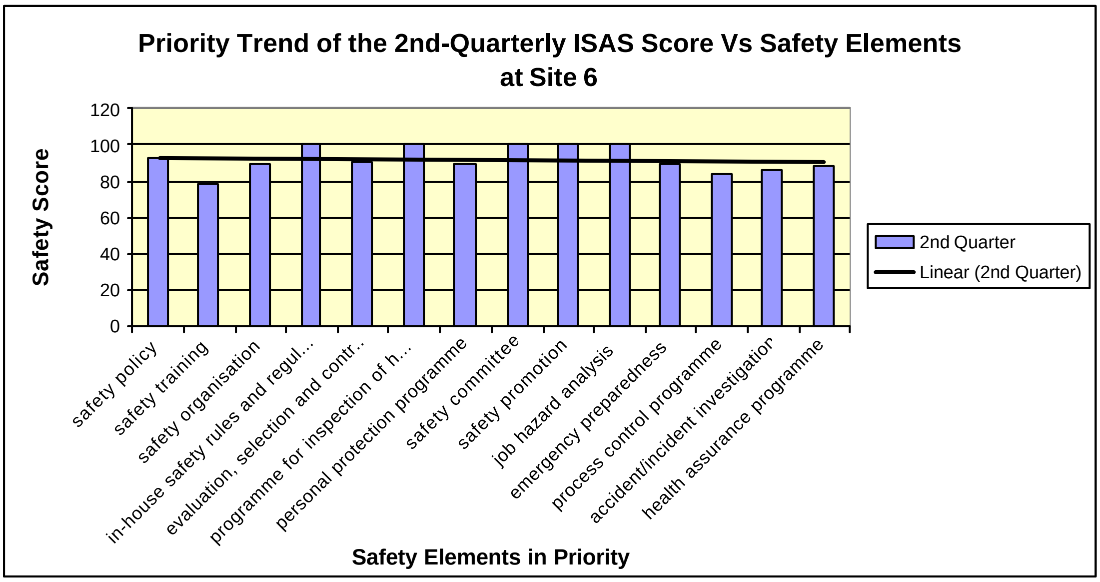



**Figure 34** The 2nd-quarterly ISAS at Site 6 shows **no directional** priority trend

## Priority Trend of 2$^{nd}$-quarterly ISAS Score Vs Safety Elements at 12 Sites Areas

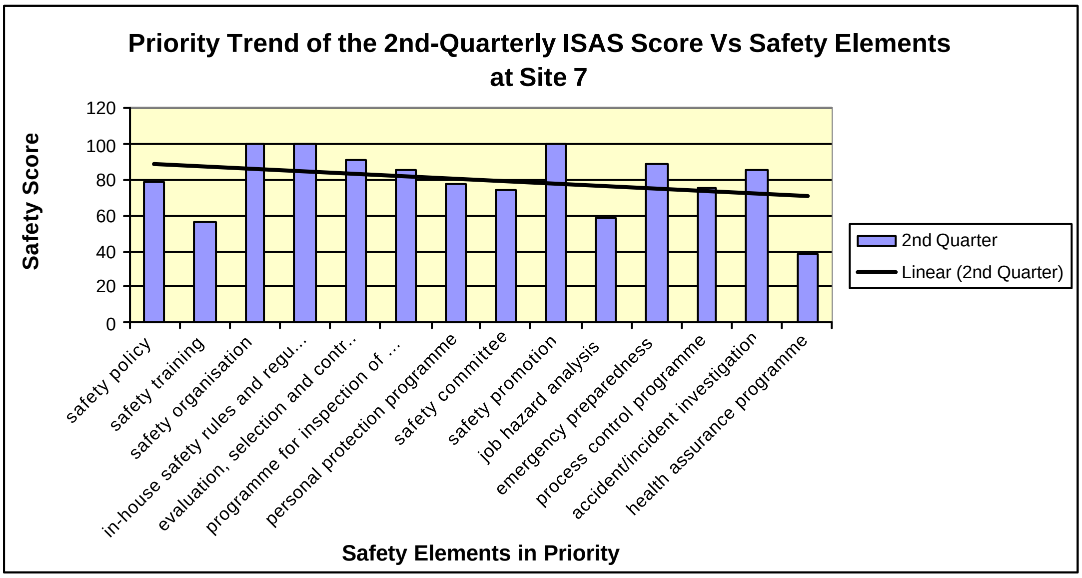



**Figure 35** The 2$^{nd}$-quarterly ISAS at Site 7 complies with the priority trend

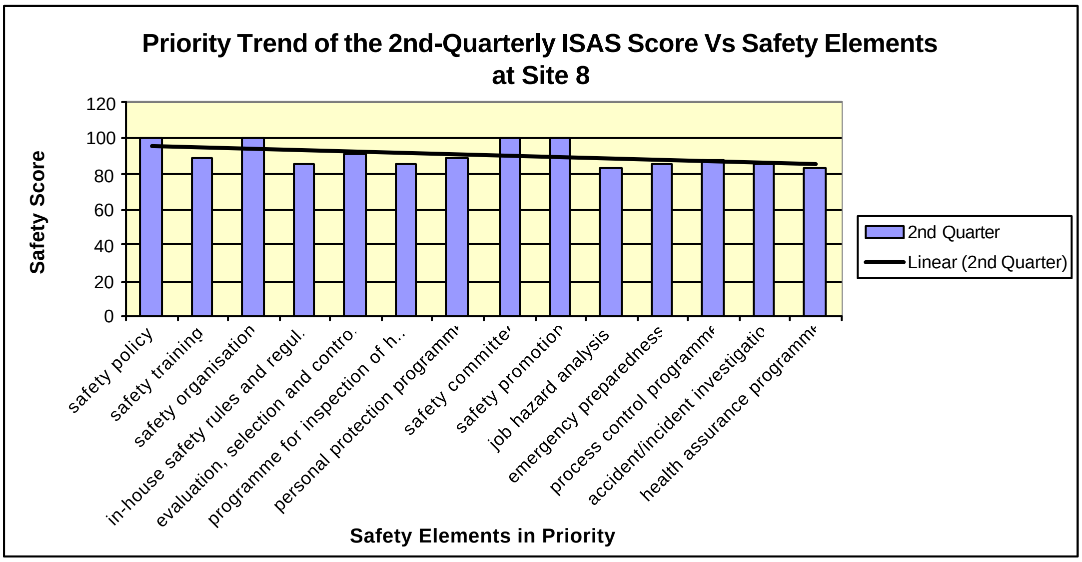
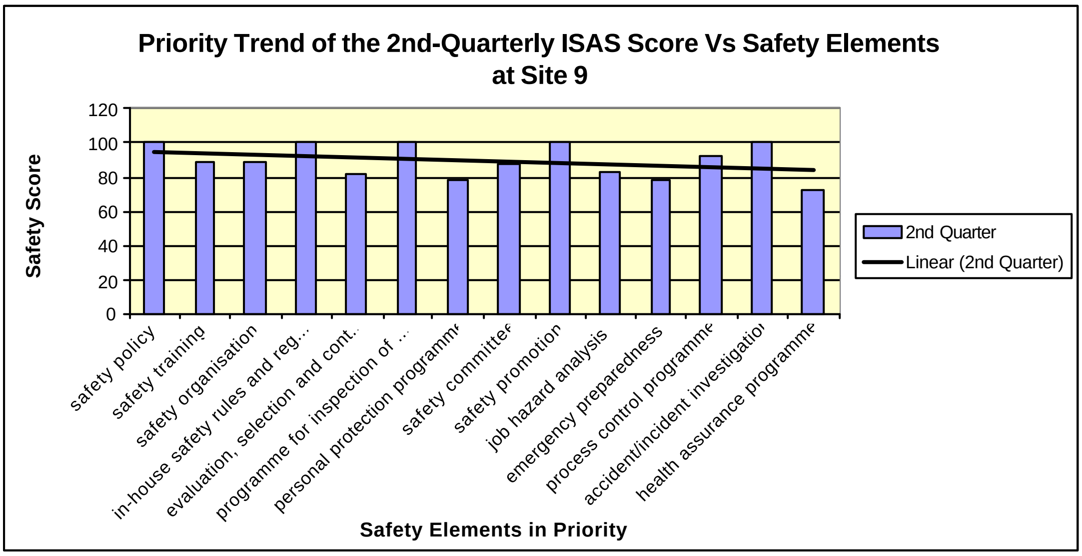



**Figure 36** The 2$^{nd}$-quarterly ISAS at Site 8 complies with the priority trend

**Priority Trend of 2$^{nd}$-quarterly ISAS Score Vs Safety Elements at 12 Sites Areas**




| **Figure 37** | The 2$^{nd}$-quarterly ISAS at Site 9 complies with the priority trend |
|---|---|

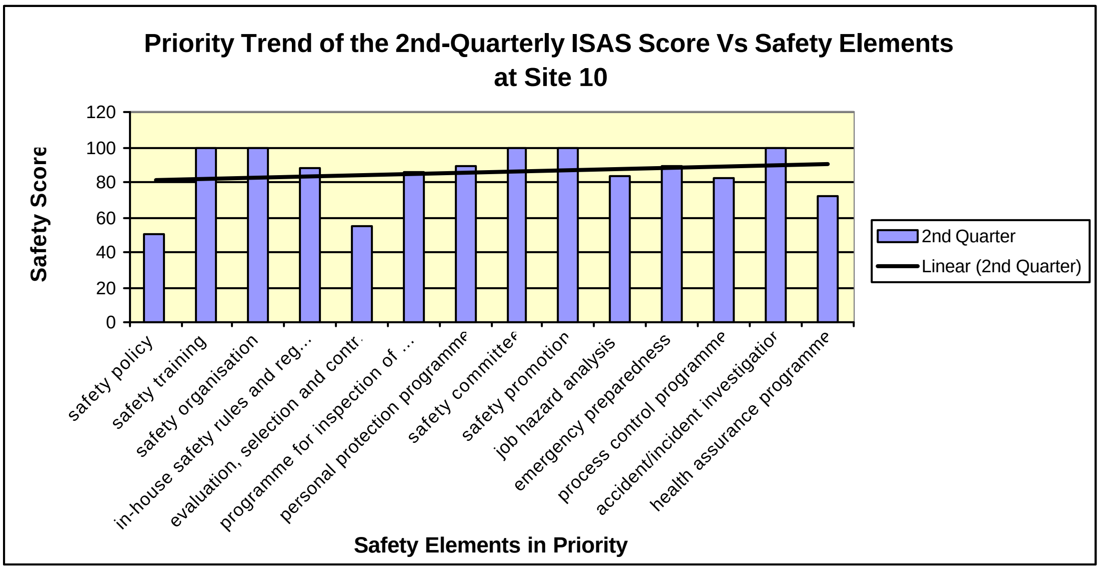
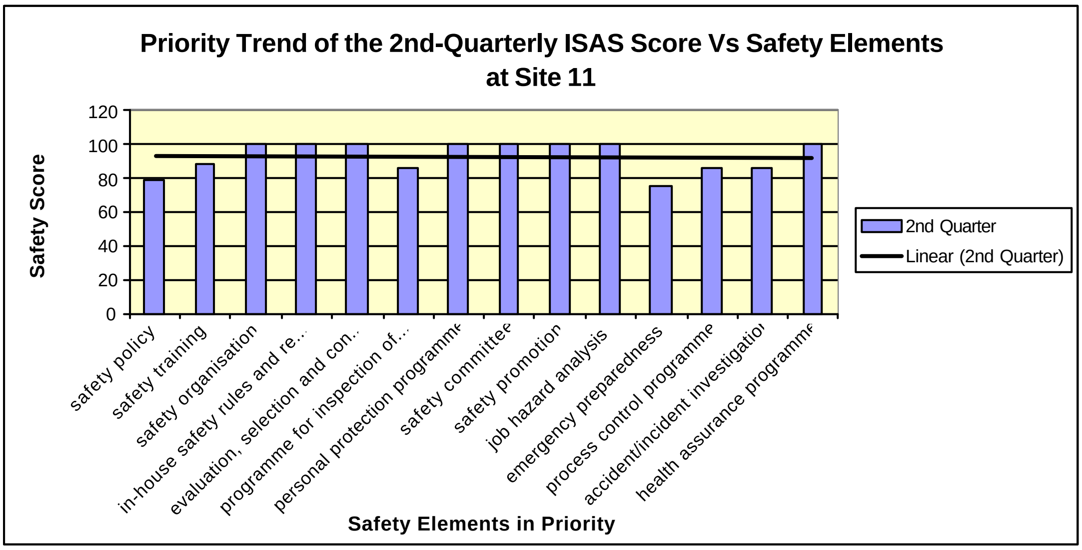
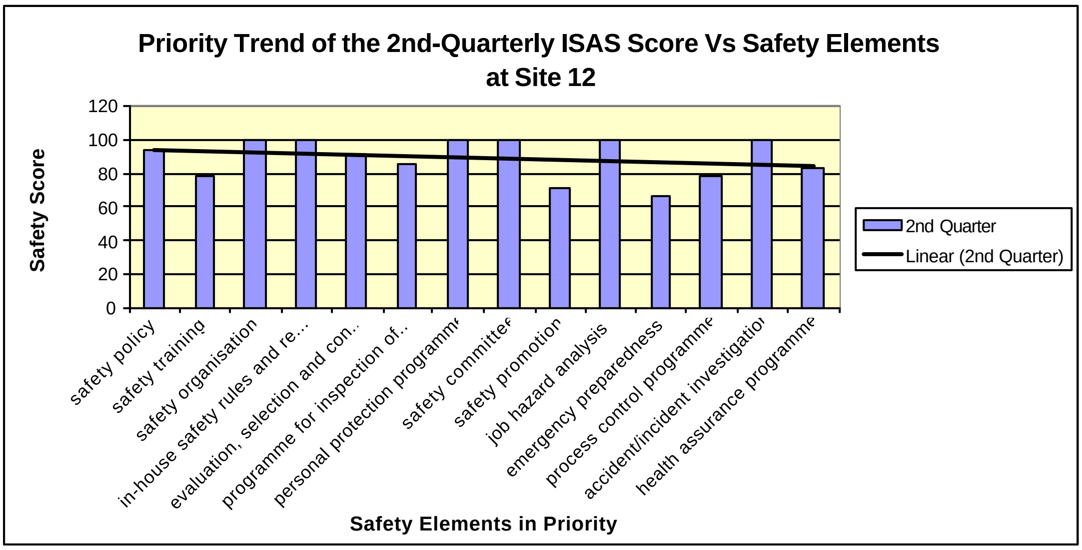



**Figure 38** The 2$^{nd}$-quarterly ISAS at Site 10 **does not comply** with the priority trend.

## Priority Trend of 2nd-quarterly ISAS Score Vs Safety Elements at 12 Sites Areas




| Figure 39 | The 2nd-quarterly ISAS at Site 11 **shows no directional** priority trend. |
|---|---|




| Figure 40 | The 2nd-quarterly ISAS at Site 12 complies with the priority trend. |
|---|---|

**Priority Trend of 3rd-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

NO QUARTERLY REPORT FOR SITE 1

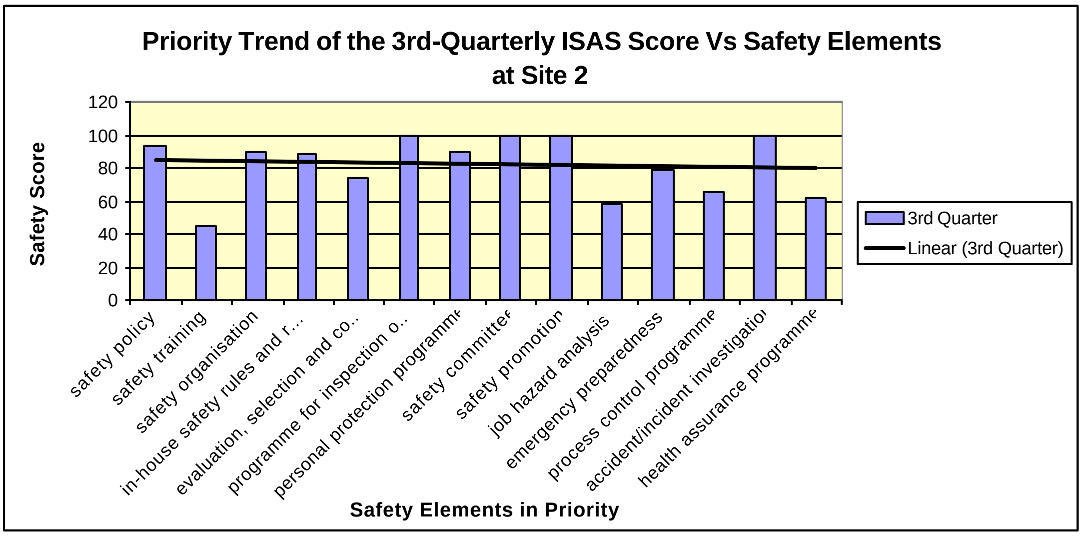



**Figure 41** The 3rd-quarterly ISAS at Site 2 complies with the priority trend.

**Priority Trend of 3rd-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

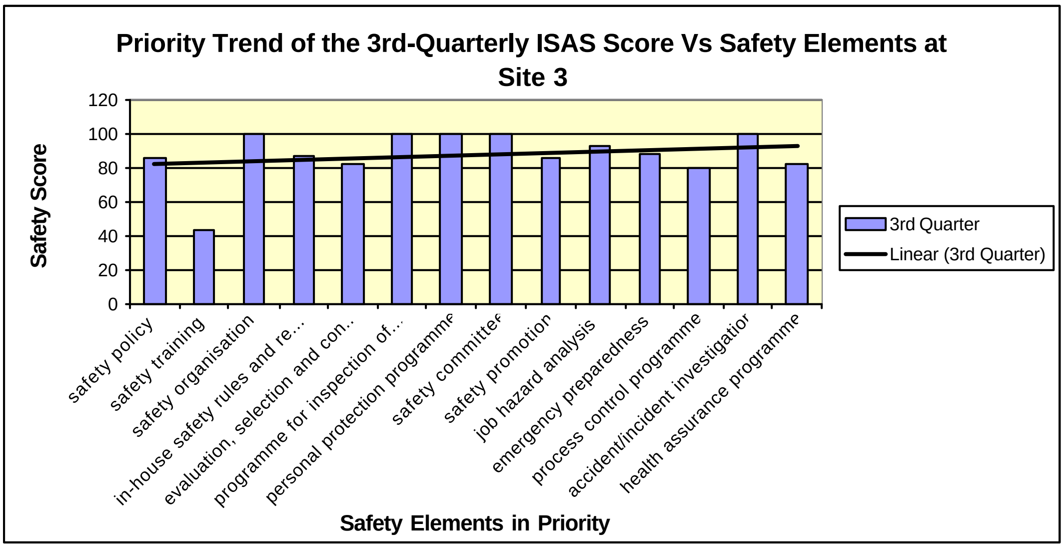



**Figure 42** The 3rd-quarterly ISAS at Site 3 **does not comply** with the priority trend.

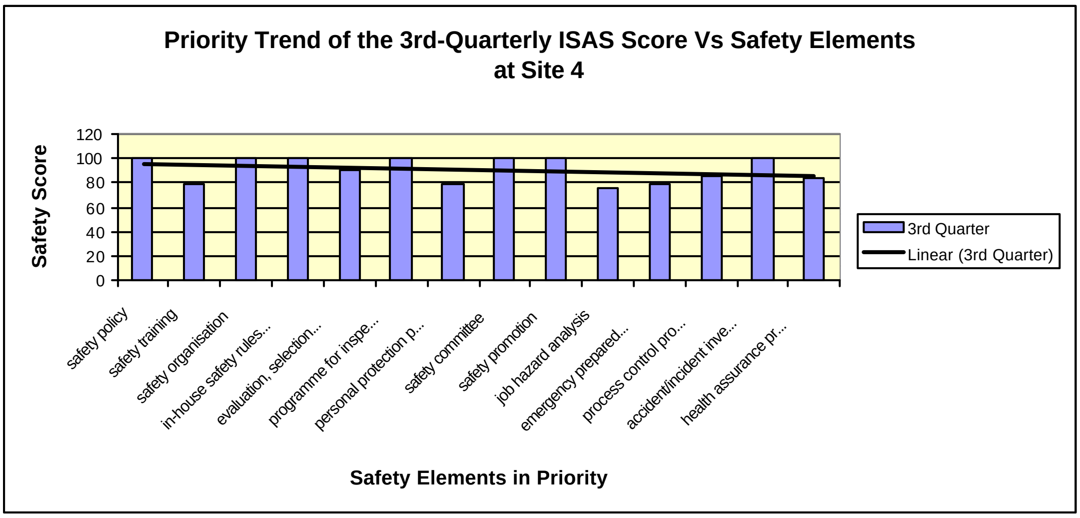



**Figure 43** The 3rd-quarterly ISAS at Site 4 complies with the priority trend.

## Priority Trend of 3rd-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

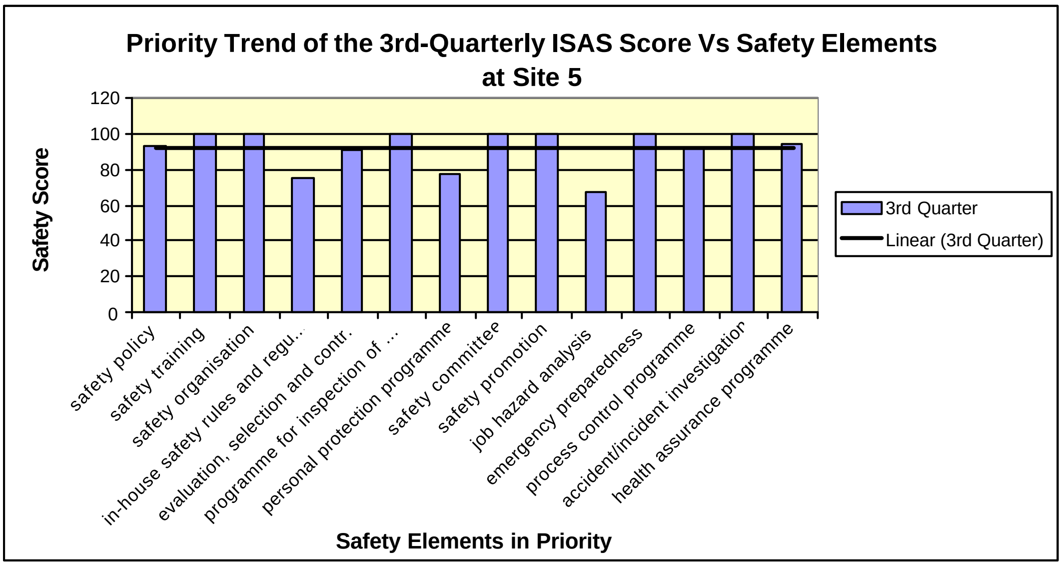



**Figure 44** The 3rd-quarterly ISAS at Site 5 **shows no directional** priority trend.

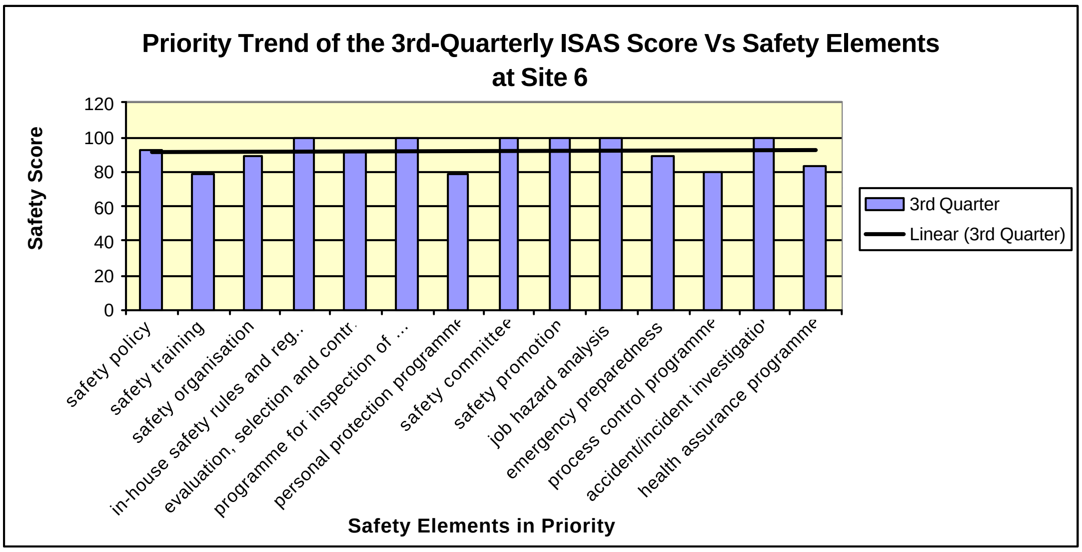



**Figure 45** The 3rd-quarterly ISAS at Site 6 **shows no directional** priority trend.

## Priority Trend of 3rd-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

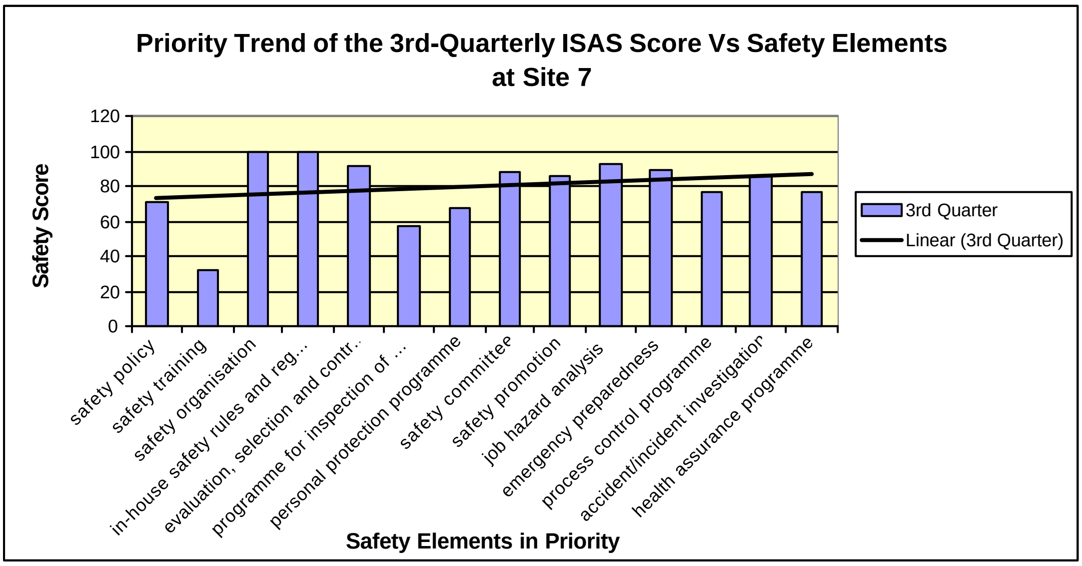



**Figure 46** The 3rd-quarterly ISAS at Site 7 **does not comply with the** priority trend.

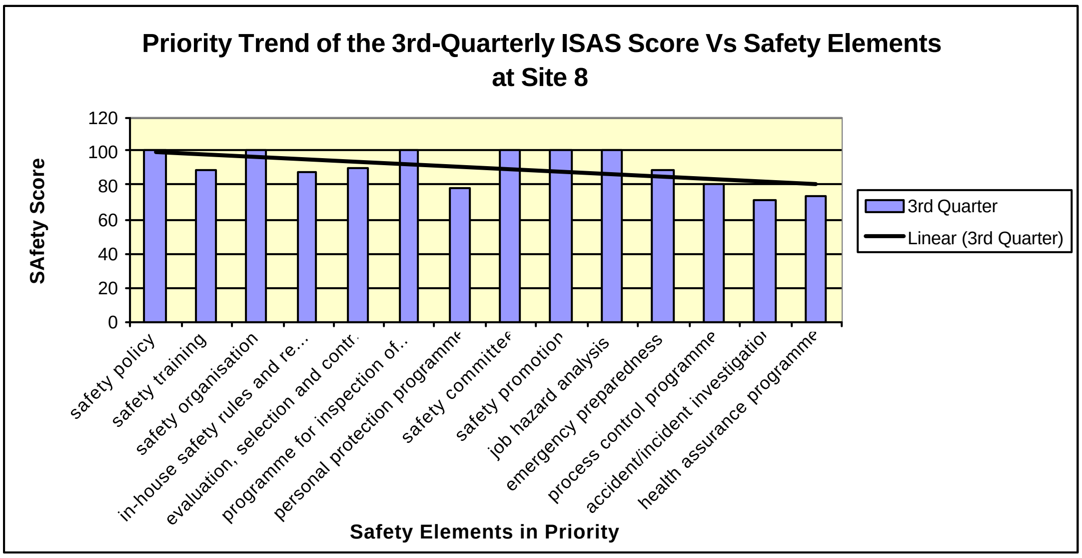



**Figure 47** The 3rd-quarterly ISAS at Site 8 complies with the priority trend.

## Priority Trend of 3rd-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

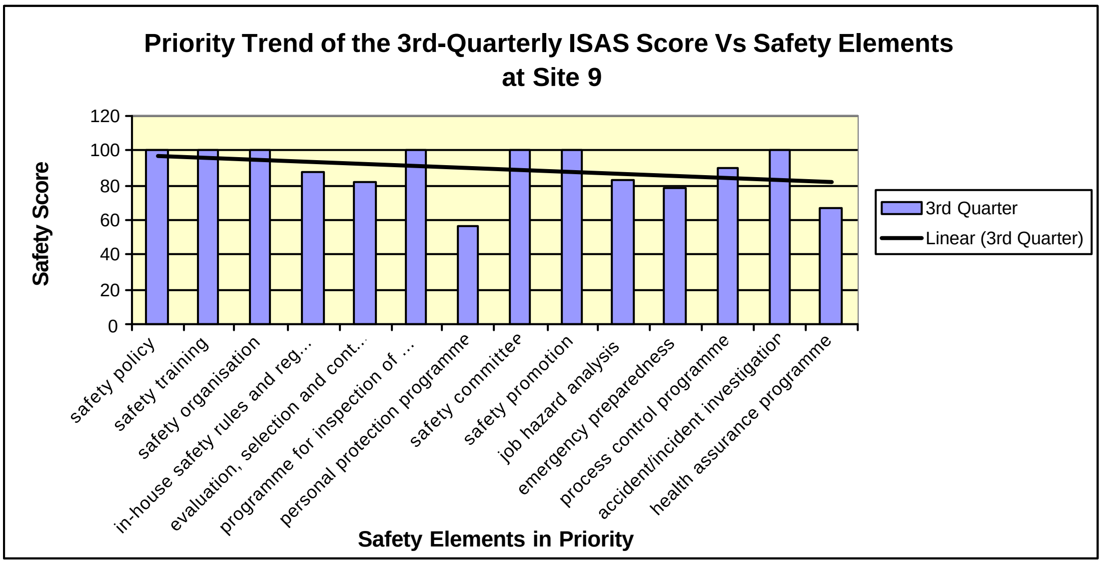



**Figure 48** The 3rd-quarterly ISAS at Site 9 complies with the priority trend.

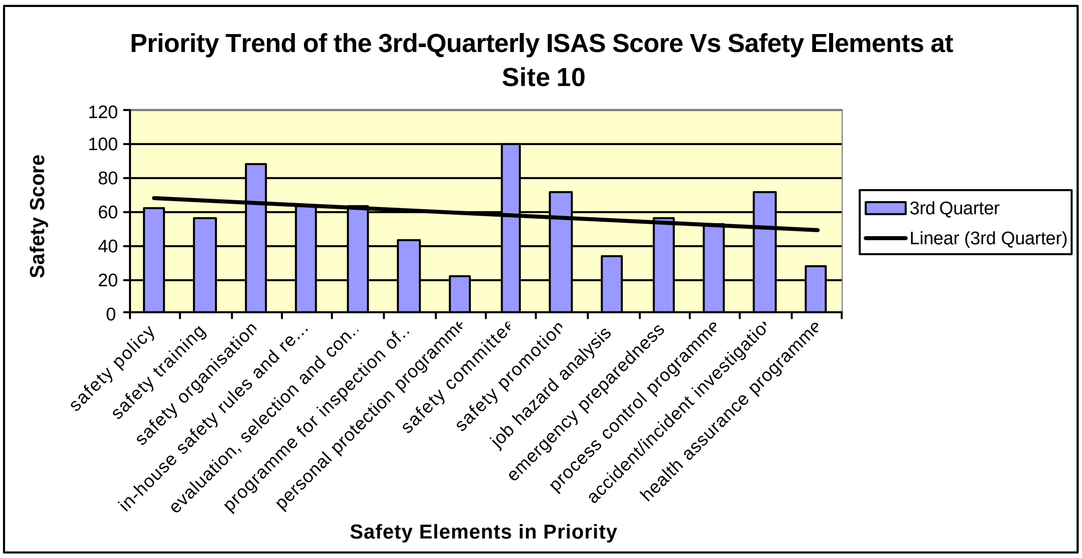



**Figure 49** The 3rd-quarterly ISAS at Site 10 complies with the priority trend.

**Priority Trend of 3rd-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

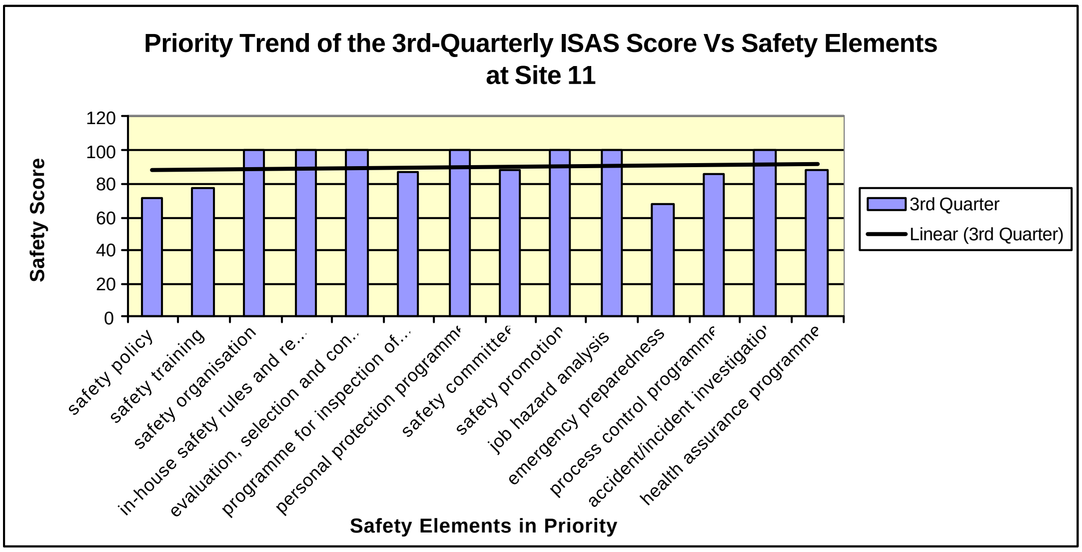



**Figure 50** The 3rd-quarterly ISAS at Site 11 **does not comply** with the priority trend.

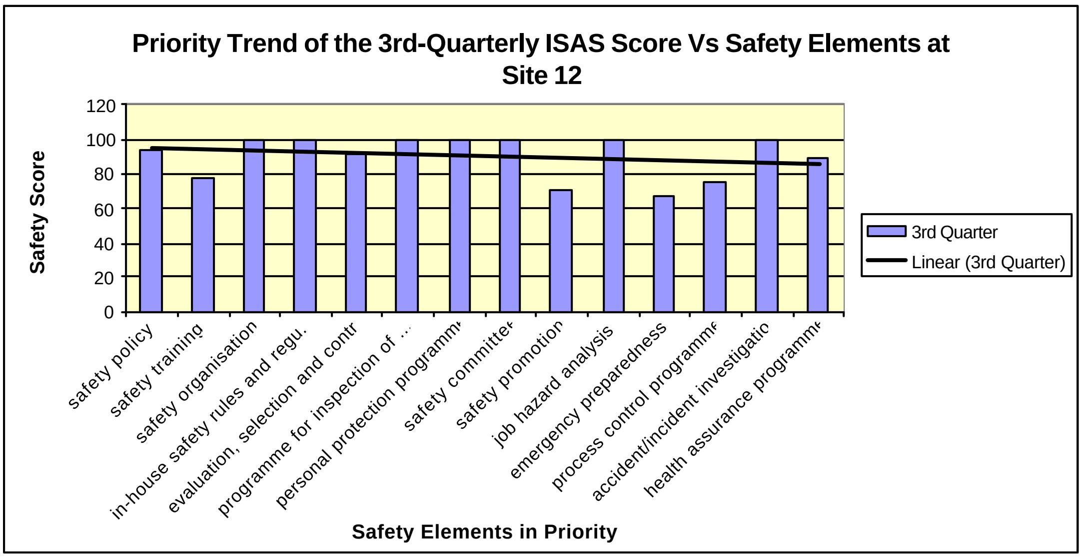



**Figure 51** The 3rd-quarterly ISAS at Site 12 complies with the priority trend.

## Priority Trend of 4$^{th}$-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

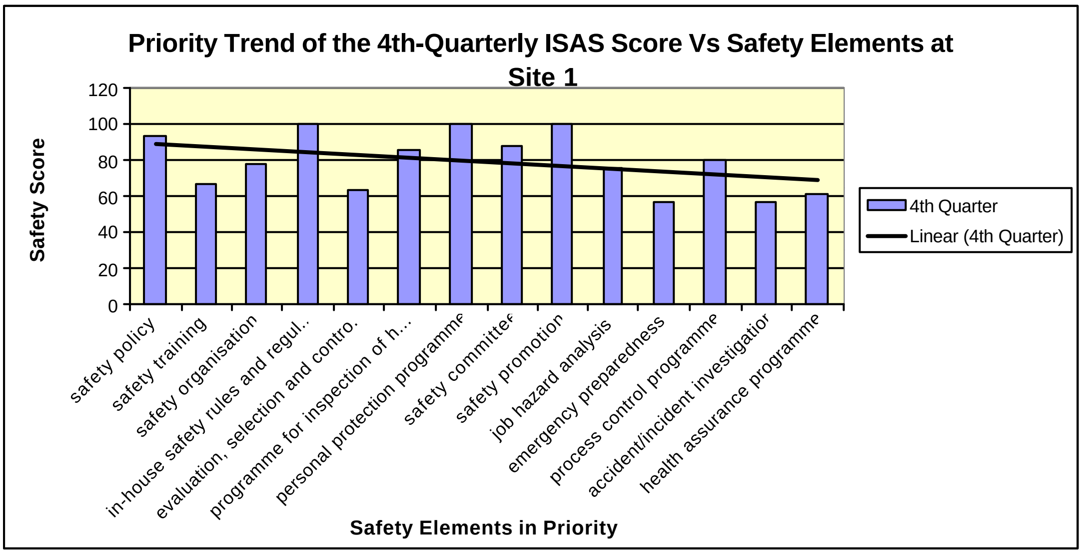



**Figure 52** he 4$^{th}$-quarterly ISAS at Site 1 complies with the priority trend.

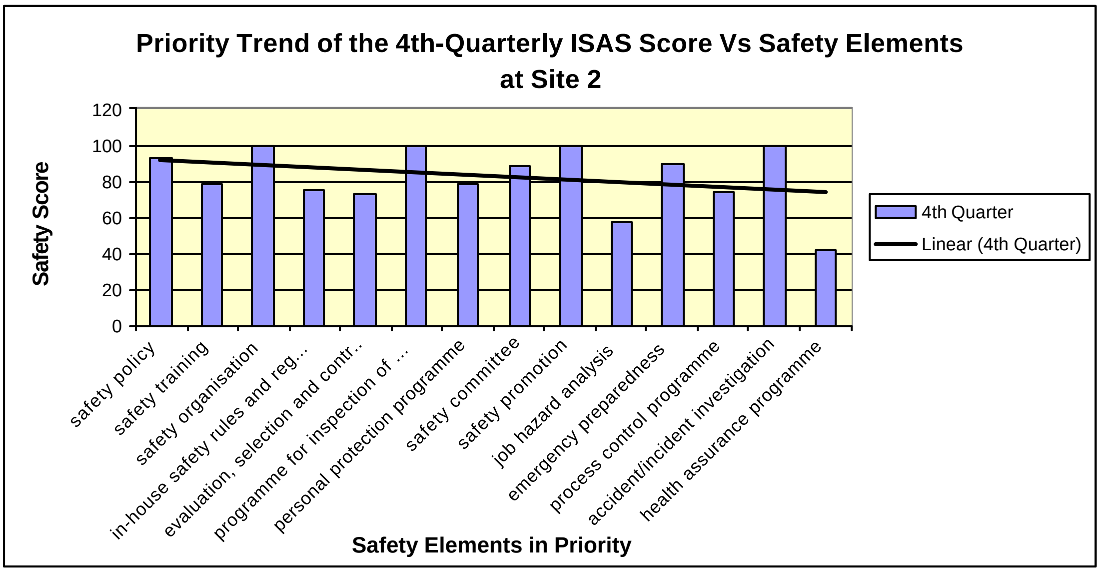



**Figure 53** The 4$^{th}$-quarterly ISAS at Site 2 complies with the priority trend.

## Priority Trend of 4th-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas

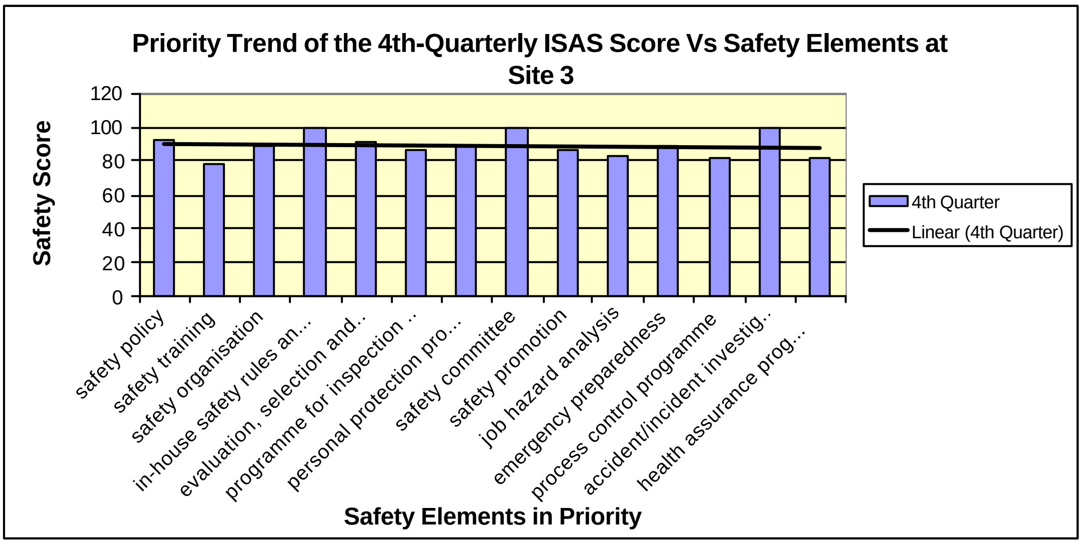



**Figure 54** The 4th-quarterly ISAS at Site 3 **shows no directional** priority trend.

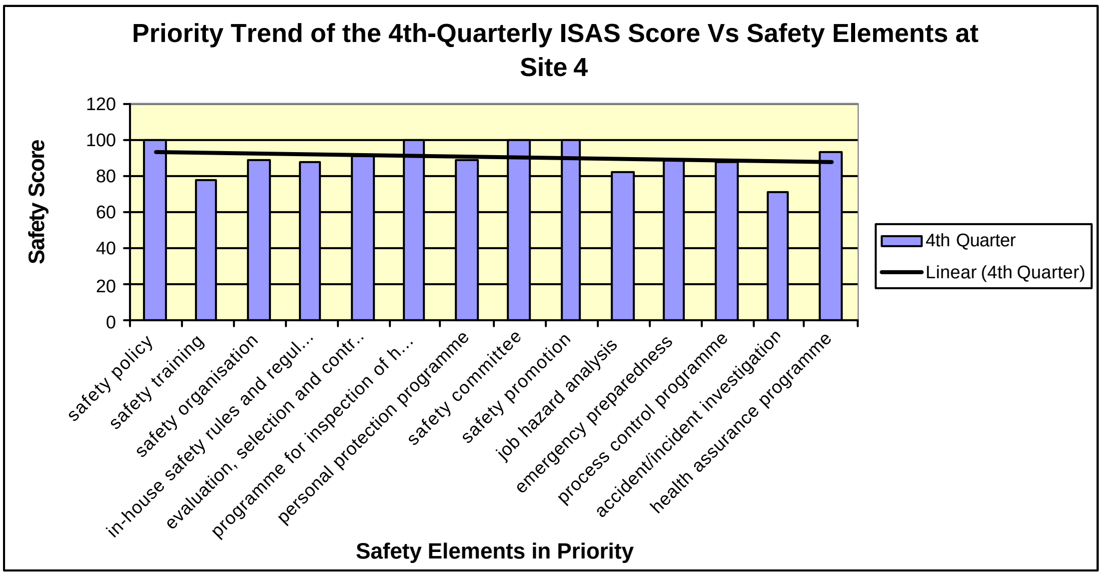



**Figure 55** The 4th-quarterly ISAS at Site 4 complies with the priority trend.

**Priority Trend of 4th-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

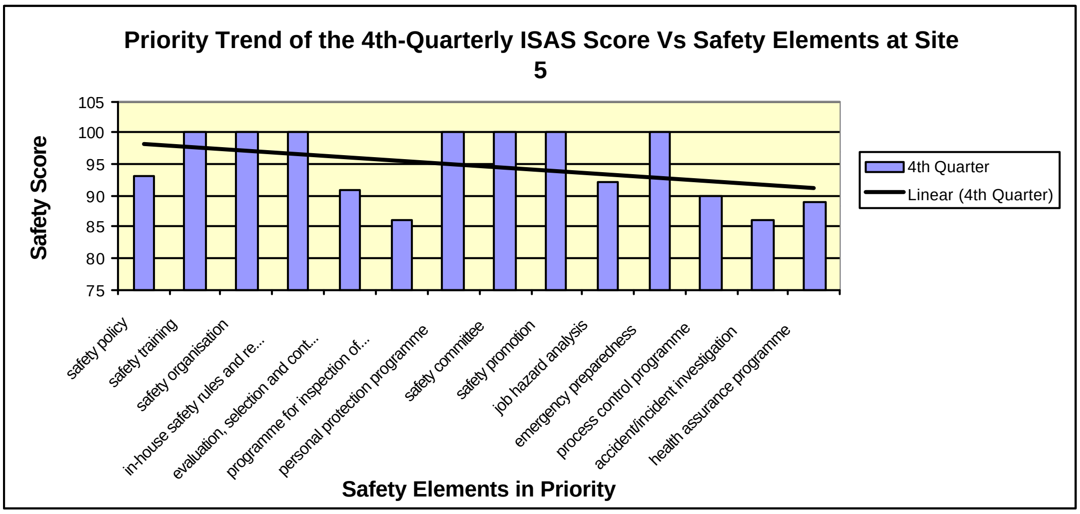


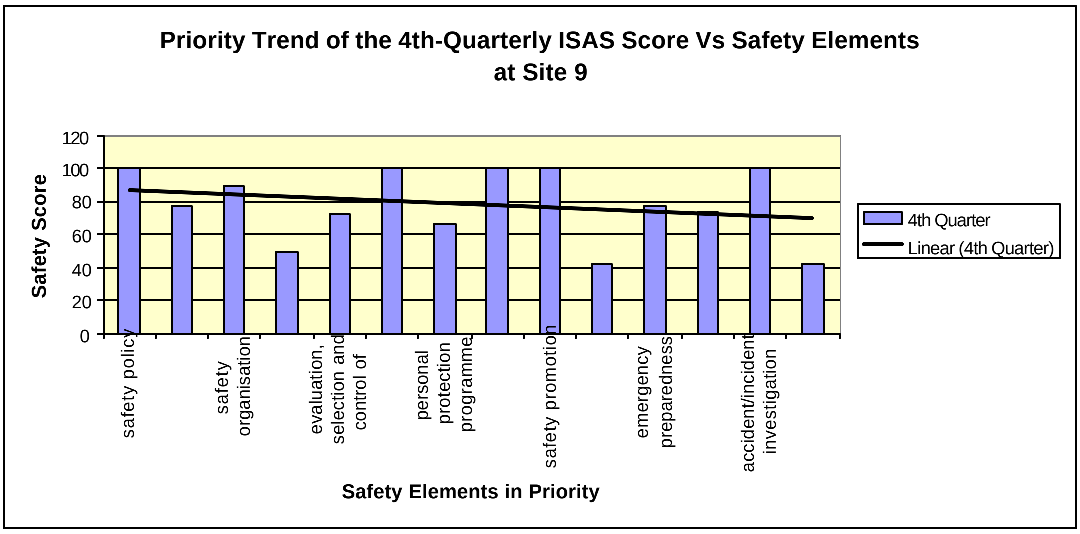

**Figure 56** The $4^{th}$-quarterly ISAS at Site 5 complies with the priority trend.

No $4^{th}$-quarterly safety ISAS report at Site 6

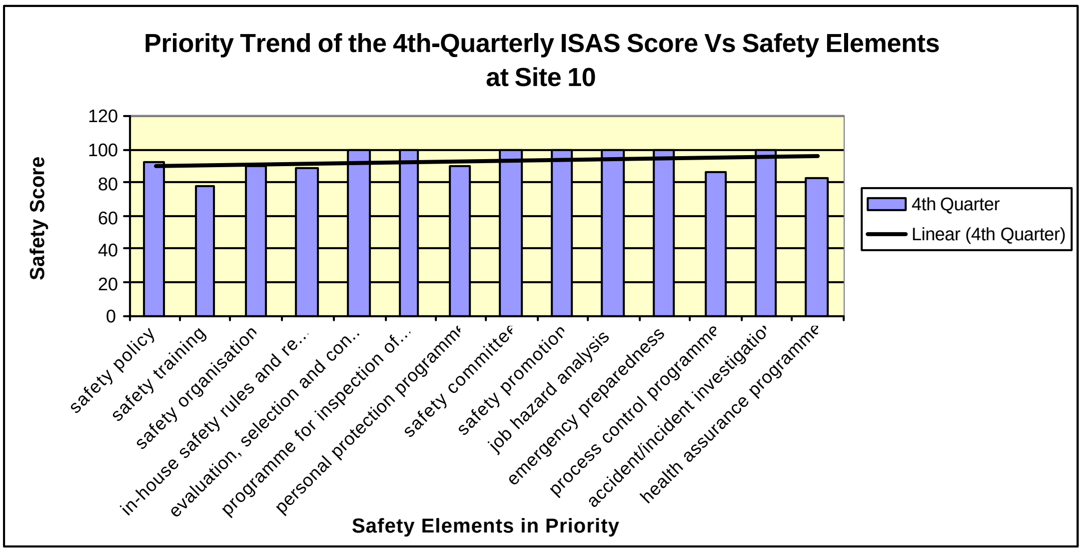
No $4^{th}$-quarterly safety ISAS report at Site 7

No $4^{th}$-quarterly safety ISAS report at Site 8

**Priority Trend of 4th-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**




| | |
|---|---|
| **Figure 57** | The 4th-quarterly ISAS at Site 9 complies with the priority trend. |




| | |
|---|---|
| **Figure 58** | The 4th-quarterly ISAS at Site 10 **does not comply** with the priority trend. |

**Priority Trend of 4th-Quarterly ISAS Score Vs Safety Elements at 12 Site Areas**

No 4th-quarterly safety ISAS report at Site 11

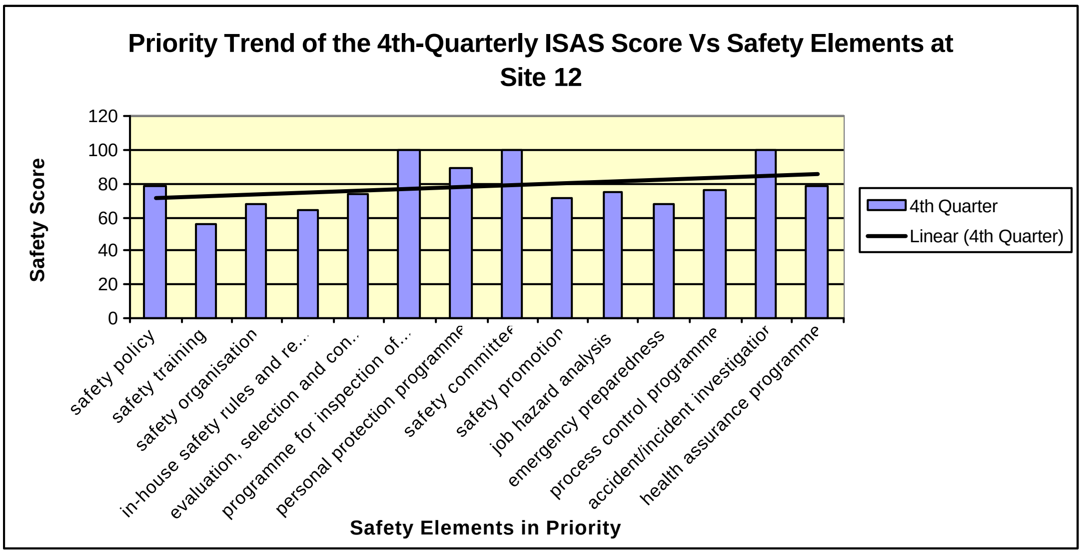



**Figure 59** The 4th-quarterly ISAS at Site 12 **does not comply** with the priority trend.