STUDY OF INFLUENCE OF SAFETY ENGINEERING AND MANAGEMENT PRACTICES IN SELECTED INDUSTRIES IN KERALA

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VINODKUMAR M.N.

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Under the Supervision of

Dr. M. BHASI

Reader, School of Management Studies

SCHOOL OF ENGINEERING
COCHIN UNIVERSITY OF SCIENCE AND TECHNOLOGY
KOCHI - 682 022

JUNE 2005

Dr. M. Bhasi M.Tech, Ph.D. (IIT KGP)
Reader

School of Management Studies
Cochin University of Science and Technology
Kochi - 682022 Kerala
Phone : (0484) 2575310 Extn. 241
Email – mbhasi@cusat.ac.in

CERTIFICATE

Certified that this thesis entitled **"STUDY OF INFLUENCE OF SAFETY ENGINEERING AND MANAGEMENT PRACTICES IN SELECTED INDUSTRIES IN KERALA"**, submitted to the Cochin University of Science and Technology, Kochi for the award of Ph.D. Degree under the Faculty of Engineering, is the record of bonafide research carried out by **Mr. Vinodkumar M.N.** under my supervision and guidance at School of Engineering, CUSAT. This work did not form part of any dissertation submitted for the award of any degree, diploma, associateship, fellowship or other similar title or recognition from this or any other institution.

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Dr. M. Bhasi
(Supervising Guide)

ABSTRACT

Keywords: Safety Management, Safety Climate, Safety Performance

In the twentieth century, as technology grew by leaps and bounds, associated hazards also grew with it. This resulted in collective efforts and thinking in the direction of controlling work related hazards and accidents. Thus, safety management developed and became an important part of industrial management. While considerable research has been reported on the topic of safety management in industries from various parts of the world, there is scarcity of literature from India. It is logical to think that a clear understanding of the critical safety management practices and their relationships with accident rates and management system certifications would help in the development and implementation of safety management systems.

In the first phase of research, a set of six critical safety management practices has been identified based on a thorough review of the prescriptive, practitioner, conceptual and empirical literature. An instrument for measuring the level of practice of these safety management practices (from the employees' perception) has been developed by conducting a survey using questionnaire in chemical/process industry. The instrument has been empirically validated using Confirmatory Factor Analysis (CFA) approach. As the second step, predictive validity of safety management practices and the relationship between safety management practices and self-reported accident rates and management system certifications have been investigated using ANOVA. Results of the ANOVA tests show that there is significant difference in the identified safety management practices among the organizations. In the next step, the relationship between safety management practices and the determinants of safety performance have been investigated using Multiple Regression Analysis. Similar analysis has been carried out to investigate the predictive capacity of determinants of safety performance on components of safety performance. The impacts of personal attributes of employees, management system certifications and accidents on determinants and components of safety performance have also been investigated using ANOVA. Results of the regression tests show that safety training predicts both safety knowledge and safety motivation, which in turn predict both safety compliance and safety participation. The inter-relationships between safety management practices, determinants of safety performance and components of safety performance have been investigated with the help of structural equation modelling. Further investigations into engineering and construction industries reveal that safety climate factors are not stable across industries. However, some factors are found to be common in industries irrespective of the type of industry.

This study identifies the critical safety management practices in major accident hazard chemical/process industry from the perspective of employees and the findings empirically support the necessity for obtaining safety specific management system certifications.

TABLE OF CONTENTS

Title **Page No.**

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
CFA	Confirmatory Factor Analysis
CFI	Comparative Fit Index
COM	Safety Compliance
GFI	Goodness of Fit Index
HSE	Health and Safety Executive
IAEA	International Atomic Energy Authority
ISO	International Standards Organization
ISRS	International Safety Rating System
KNO	Safety Knowledge
MC	Management Commitment
MOT	Safety Motivation
NIOSH	National Institute for Occupational Safety and Health
NNFI	Bentler-Bonnet Non-Normed Fit Index
OECD	Organization for Economic Cooperation and Development
OHSAS	Occupational Health and Safety Assessment Series
OSHA	Occupational Safety and Health Act
PAR	Safety Participation
RMSR	Root Mean Squared Residual
SC	Safety Communication and Feedback
SP	Safety Promotion Policies
SR	Safety Rules and Procedures
ST	Safety Training
TLI	Tucker- Lewis Index
TQM	Total Quality Management
VIF	Variance Inflation Factor
WI	Worker Involvement in Safety

CHAPTER 1

INTRODUCTION

Section 1.1 describes the development of safety management in industries. Section 1.2 discusses safety management in Indian industries. A brief description on methods of measuring safety management is presented in Section 1.3. Section 1.4 contains the research issues followed by research objectives in Section 1.5. Research methodology adopted for this study is presented in Section 1.6. Section 1.7 describes the organization of the thesis.

1.1 DEVELOPMENT OF SAFETY MANAGEMENT

The Industrial Revolution that took place in the eighteenth century changed forever the methods of producing goods. The most important change was the substitution of machines for people. This resulted in organization of work into large units called "factories", followed by direct supervision of the manufacturing process and efficient division of work among the labor. As the industrial revolution continued its rapid growth, unsafe production methods exacted a heavy toll on the workforce in terms of job-related injuries and deaths (Felton, 1986).

In the twentieth century, as technology grew by leaps and bounds, associated hazards also grew with it. This resulted in collective efforts and thinking in the direction of controlling work related hazards and accidents. A group of delegates including safety professionals, management leaders, public officials and insurance specialists who met in a national safety meeting in New York in the year 1913, had a desire to attack the problem of occupational health and safety which most people considered either unimportant or insoluble. This resulted in the birth of a voluntary organization, named "National Safety Council", which helped to create the safety movement, as we know it today. Later, similar voluntary organizations such as International Labor Organization, British Safety Council etc. came up with support from industries in various parts of the world.

Early legal action in industrial safety took the form of laws to regulate and investigate industry working conditions, death and injury rates. The next phase was largely concerned with workers' compensation payments. In subsequent years, governments gradually expanded their roles in regulating industry on safety matters.

In 1970, 'Occupational Safety and Health Act, (OSHA)' was passed in United States of America as a comprehensive national safety law. Safety took a new direction and meaning as a result of OSHA. Similar steps were followed by other countries, such as United Kingdom (Health and Safety at Work Act, 1974), Australia (Victoria Occupational Health and Safety Act, 1985) etc.

As a result of the above Acts, Safety and health of workers became a major concern and priority of management. In addition to the losses due to downtime, costs for workers' compensation insurance, medical and administrative expenses resulting from disability, death and impaired productivity, they were liable to face serious monetary penalties and criminal sanctions from the government side, for non-compliance of law. Therefore, safety management became an important part of industrial management.

1.1.1 Safety management in industries

The systematic and planned top management driven activity that aims at controlling the health and safety hazards of its employees is called safety management (Booth and Lee, 1995). The primary aim of safety management is to intervene in the causation process that leads to accidents. This includes above all, the active recognition of both visible and latent hazards. However, safety management is more than just a hazard identification system. It is an overall system for ensuring that safety activities are properly planned, effectively implemented, and that follow up system is arranged. Typically, safety management includes activities such as risk analysis, arrangement of safety training, accident and near-miss investigation, safety promotion and assessment of human reliability. In an effective safety management system, these activities are assigned to all the different hierarchical levels of the organization (Booth and Lee, 1995; Grimaldi and Simmonds, 1975).

1.1.2 Traditional safety management

The form of safety management followed by most of the industries, called as 'traditional safety management', has the following characteristics (Smith, 1996; Weinstein, 1996; Hansen, 1993).

- Top/down communication.
- Minimal employee participation.
- Dependence on discipline to influence safety behaviour.
- Centered on technical requirements aiming at short-term results.
- Safety techniques are used after accident and injury.
- Safety programme is not integrated with the rest of the functions of an organization.
- Safety director is responsible for safety programme, but does not have the authority to make changes.

In spite of these efforts to promote health and safety of employees, some major industrial disasters took place between 1970 and 1990 in various parts of the world. Scientific investigations into these accidents by researchers pointed out some major deficiencies in the existing safety management system. Powell and Canter (1985) observed that "more than half of the industrial accidents are attributable to deficiencies in the human and management component than to unforeseeable weaknesses in the technical component". These findings prompted further studies to improve safety management. After studying more than 200 companies, Dumas (1987) discovered that programmes of quality and programmes of safety have similar components. He concluded, "Safety is a dimension of quality, after everything, the elimination of defects includes the elimination of practices of unsafe work". According to Minter (1991), "if one looks at safety as a consequence of making things well, then the programme will undoubtedly bear quality".

1.1.3 Safety integrated with quality

Recognizing the need of ensuring quality in safety management, many companies started to deviate from traditional safety management to embrace a new system approach to safety management in the 1990s. This method, according to Petersen (1994), with philosophies of quality in conjunction with safety, has the following salient features:

- Safety becomes a system, more than a programme.
- Progress is not measured by injury ratios.
- Statistical techniques drive the efforts of continuous improvement.
- Investigation of accidents and following up corrective actions.
- Technical principles and tools for statistical control of process are used.
- Emphasis is placed on improving the system.
- Benefits are provided for people who discover illegal situations.
- Participation of workers in problem solving and decision-making.
- Ergonomic well-being is projected inside the place of work.
- The traps within the system that cause human errors are eliminated.

Companies in developed countries have been practicing quality integrated safety management since two decades. Different safety management practices are followed voluntarily in those industries to improve health and safety of employees at workplace.

1.2 SAFETY MANAGEMENT IN INDIAN INDUSTRIES

In India, The Factories Act, 1948 (Central Act 63 of 1948) came into force on 1.4.1949 to ensure the healthier and safer work atmosphere for the workers, and for improving the general welfare of workers. The Act sets out the broad outline of the measures for achieving the object of protecting the workers from industrial and occupational hazards and for their welfare. Power is given to state governments to frame rules regarding the details of the measures for various types of factories so that the local conditions prevailing in the State are appropriately reflected in the enforcement.

Government of Kerala has framed various rules such as 'Kerala Factories Rules, 1957', 'Kerala Factories (Welfare Officers) Rules, 1957', 'Control of Major Industrial Accident Hazard (Kerala) Rules, 1993', etc to provide guidelines for the enforcing agencies.

National Safety Council was set up by Ministry of Labor, Govt. of India in 1966, as a non-profit making, non-political voluntary organization to generate, develop and sustain a voluntary movement at the national level to promote awareness of safety, health and environment so as to supplement and strengthen government efforts in this field. They have local chapters in all states and offer consultancy services to industries in all areas of safety management.

Safety management attained significance in India only after the Bhopal gas tragedy in 1984. Gupta (2002) points out the major causes of this accident as, indifferent attitude of the management towards safety and lack of enforcement of existing regulations by regulatory bodies. Learning lessons from Bhopal disaster, most of the industrial organizations in India have made considerable investments in safety related infrastructure, equipment and training. Enforcement rules and regulations have also been made more stringent with a number of amendments in the Acts and Rules.

Many organizations from chemical/process, manufacturing, engineering and construction industries have gone for management system certifications such as ISO 9001, OHSAS 18001 and ISRS certifications. With globalization and opening up of our economy, Indian organizations from various sectors have started to take initiatives to get the above certifications to compete in the international market. OHSAS 18001 and ISRS are occupational health and safety management based where as ISO 9001 is based on quality management. Since "Safety" is a dimension of "Quality", when any attempt for quality management is made, it also ensures safe work environment for its employees (Carder and Ragan, 2003).

Every Indian organization is supposed to prepare a 'Safety Manual' based on 'The Factories Act, 1948' and state 'Factory Rules' to take care of the health and safety of its employees, covering the various manufacturing activities employed in the company. To what extent these are practised in reality depends on the commitment of the top management of the organization. Committed managements subsequently adopt various safety management practices to safe guard their employees from work related hazards whereas others try to manage safety of employees by encouraging them to work safely. A scientific investigation into this only can reveal what is happening inside the organization so that improvement methods can be suggested.

1.3 MEASURING SAFETY MANAGEMENT IN INDUSTRY

Different safety management practices are adopted in industries by managements in advanced countries to promote health and safety of workers. Not all of them are universally adaptable due to social and cultural factors prevailing in each country. However, levels of these safety management practices need to be assessed especially in high hazard industries. It can be argued that these are predictive measures enabling safety condition monitoring (Flin, 1998), which may reduce the need to wait for system to fail, in order to identify weaknesses and to take remedial actions. This can also be conceptualized as a switch from 'feedback' to 'feed forward' control (Falburch and Wilpert, 1999). This shift of focus has been driven by the awareness that organizational, managerial and human factors rather than purely technical failures are prime causes of accidents in high reliability industries (Weick et al., 1999).

Safety audit is widely accepted as a method of safety management measurement in industries (Kennedy and Kirwan, 1998). However, safety audits have inherent measurement biases at various levels, as it examines what is documented, but fails to reveal what is truly existing in practice (Mearns et al., 2003; Kirwan, 1998). Survey among the workforce using valid and reliable self-reporting questionnaire is reported to be the most effective method for measuring the level of safety management practices (Flin et al., 2000; Mearns et al., 2003). For a successful organization, these measurements need to have positive relationships with safety outcomes such as accident rate or injury rate.

1.4 RESEARCH ISSUES

Most of the studies in the area of industrial safety have been reported from developed countries. India, being a large country with high population and abundant skilled manpower, is a suitable place for safety related research. Review of literature reveals that there is not enough research evidence from India in the area of industrial safety.

Antecedents of safety performance (safety management practices) must be instrumental in enhancing the level of determinants of safety performance (safety knowledge and safety motivation), which are in turn related to components of safety performance (safety compliance and safety participation). It appears that this area has not been examined rigorously, especially in India. The way by which these determinants and components of safety performance are related to personal attributes of employees is also worth investigating.

Since more and more organizations are embracing safety specific or other type of quality certification in India, the level of safety management practices and determinants and components of safety performance in those firms and their relationship with safety outcomes become an area of research interest. There is wide scope for safety climate studies in India in various industries to identify the underlying factors and also to verify the claim of Coyle et al. (1995), that safety climate factors are not universally stable but are culture and industry dependent. The diversity in language, literacy level and culture of Indian labour add further scope for such studies.

Another area of research potential is structural equation modelling of safety performance where complex relationships can be modeled and tested which are not possible by other multivariate techniques. There is very little evidence in literature on safety performance model building relating antecedents, determinants and components of safety performance.

1.5 RESEARCH OBJECTIVES

The research objectives considered in the current study are as follows:

- To identify critical safety management practices in industries;
- To develop and validate an instrument to measure critical safety management practices, by an empirical study in chemical/process industry;
- To find out the relationship between safety management practices and accident rates in industries;
- To explore the impact of system certification on safety management practices in industries;
- To identify and validate determinants and components of safety performance;
- To explore the predictive capacity of safety management practices on determinants of safety performance;

- To explore the predictive capacity of determinants of safety performance on components of safety performance;
- To study the impact of accident rates, system certification and personal attributes such as qualification, age, tenure, job category and accident history on determinants and components of safety performance;
- To propose a model for safety performance connecting management practices, determinants of safety performance and components of safety performance;
- To explore the underlying factors in safety climate and its empirical validation;
- To study the impact of accident rates and system certification on safety climate factors;
- To test the validity of safety climate factors obtained in chemical/process industry with engineering and construction industries and to find safety climate factors in engineering and construction industries if necessary.

1.6 RESEARCH METHODOLOGY

The first part of research work presented in this thesis is the development of an instrument for measuring safety management practices, determinants of safety performance and components of safety performance. From review of related literature and safety management theory, and interactions with safety professionals and management experts, six critical safety management practices, two determinants of safety performance and two components of safety performance were identified. Initially, a draft questionnaire containing eighty two items, covering the above dimensions and safety of work environment was prepared. This was subsequently fine tuned to a sixty two item instrument after conducting a preliminary survey and discussions with safety professionals and management experts. Responses to these items were solicited on five point Likert scale from "Strongly disagree" to "Strongly agree". Ten demographic questions were also included for use in various analyses.

Main part of the survey using this instrument was carried out in eight large major accident hazard chemical/process industrial units in Kerala in the year 2002. Responses were collected from workmen and first line supervisory staff from various departments.

1806 completed questionnaires were received with a response rate of 71%. This data were used for the analysis to achieve the objectives of this research.

Finally, the same instrument was used for survey in construction and engineering industries as a part of cross validation. Employees from ten building sites belonging to three construction companies, and two engineering industrial units took part in this survey.

1.7 ORGANIZATION OF THE THESIS

The thesis is presented in eight chapters. The remaining seven chapters are organized as follows:

In Chapter 2, a review of literature on safety climate, safety culture and safety management in different industries is presented. Observations from the literature review and motivation for the present study are also discussed here.

The critical safety management practices in industries are identified and discussed in Chapter 3. This is followed by a discussion on the development of an instrument for measuring the level of safety management practices. Validation of the instrument using the data collected through survey using questionnaire among eight major chemical/process industrial units in Kerala is also presented in this chapter.

The relationship between safety management practices and accident rate in industries is presented in Chapter 4. This is followed by a discussion on system certification in industry and an investigation on the relationship between safety management practices and system certification.

In Chapter 5, the determinants and components of safety performance are identified and validated. This is followed by investigation on the relationship between safety management practices and determinants and components of safety performance. Impact of personal attributes of employees, system certification and accident rate on determinants and components of safety performance is explored here and the findings are reported. Finally, a safety performance model is proposed and the test results are presented at the end of this chapter.

The underlying factors in safety climate are explored and presented in Chapter 6. The predictive validity of safety climate factors and their relationship with accidents and system certification is also investigated and presented here.

Chapter 7 deals with the fit of safety climate model developed for chemical/process industry in construction and engineering industries followed by determination of safety climate factors for the latter two.

A summary of the results and findings of the research are presented in Chapter 8. The limitations of this research work and scope for future research are also presented here along with the conclusions of the researcher.

CHAPTER 2

LITERATURE SURVEY

Section 2.1 explains the concept of safety culture and safety climate. Section 2.2 describes the research works done on safety culture/climate in various industries. Section 2.3 critically examines the literature on safety management. In section 2.4, the gaps in literature are discussed and the motivation and objectives of the present study are explained.

In the past, industry has concentrated its efforts on reducing injuries by focusing on physical conditions such as the guarding of equipment or other factors that exposed employees to energy sources (Heinrich, 1959; Kohn et al., 1996). Industry has also focused on addressing primarily those issues that OSHA and other agencies regulate and are likely to check during an inspection at a facility (Smith, 1979; Weil, 1994).

Exhaustive inquiries into the major disasters of recent years, e.g. the escape of gas at Bhopal, the King's Cross Underground Station fire, the sinking of the *Herald of Free Enterprise*, the Clapham Junction rail accident, the Chernobyl nuclear accident, the Piper Alpha oil rig fire etc. came to the same conclusion that, despite the adoption of the full range of engineering and technical safe guards, complex systems broke down calamitously because the people running them failed to do what they were supposed to do (Lee, 1998). On the other hand, in research works on occupational health and safety, the need to recognize the importance of worker behavior was commented on extensively by Margolis (1973), who found that engineering solutions to accidents were in themselves insufficient in the prevention of accidents. Similar observation was made by Saari (1990) also, who suggested that, after a certain point, technology cannot achieve further improvements in safety but organizational and cultural factors become important.

Margolis (1973) stressed that the individual attitudes of employees towards safety were directly related to managerial attitudes towards safety. Beck and Feldman (1983) reached similar conclusions arguing that the implementation of safe work practices is dependent on the expectations of employees. Yet, very little work has been undertaken to systematically measure expectations and attitudes of workers towards occupational health and safety at various levels of organizations. For that matter, there has been little research aimed at determining whether identifying attitudinal problem areas within an organization will be of any benefit as far as occupational health and safety is concerned. This is where the concepts of safety climate and safety culture come in to picture, as they represent the work environment and underlying perceptions, attitudes, and habitual practices of the workforce at all its various levels (Kennedy and Kirwan, 1998).

2.1 CONCEPT OF SAFETY CULTURE/CLIMATE

The concept of 'safety culture' has largely developed since the OECD Nuclear Agency (1987) observed that the errors and violations of operating procedures occurring prior to the Chernobyl disaster were evidence of a poor safety culture at the plant (Pidgeon and O'Leary, 2000). Safety Culture has been defined as "that assembly of characteristics and attitudes in organizations and individuals, which establishes that, as an overriding priority, plant safety issues receive the attention warranted by their significance" (International Atomic Energy Authority (IAEA), 1986). Safety culture is important because it forms the context within which individual safety attitudes develop and persist and safety behaviors are promoted (Zohar, 1980). Safety culture is a stable and enduring feature of the organization and is a sub-element of the overall organizational culture (Kennedy and Kirwan, 1998).

Safety climate is regarded as a manifestation of safety culture in the behavior and expressed attitude of employees (Cox and Flin, 1998), and is a more tangible expression of the safety culture in the form of symbolic and political aspects of the organization (Kennedy and Kirwan, 1998). Safety climate is best considered a subset of organizational climate. Safety climate factors will characterize and influence the deployment and effectiveness of the safety management resources, policies, practices and procedures. It has been suggested that safety climate surveys are a much better predictor of an organizational safety performance as it overcomes many of the limitations of traditional safety measures such as reporting biases and after-the-fact measurement.

Assessments of safety climate are used as an indicator of overall safety culture in an organization. Culture in general, and safety culture in particular, is often characterized as an enduring aspect of the organization with trait-like properties and not easily changed. Climate, on the other hand, can be conceived as a manifestation of organizational culture (Schein, 1985) exhibiting more state-like properties. The nature of culture and climate and their relationship has also been related to the concepts of personality and mood (Cox and Flin, 1998), where culture represents the more trait-like properties of personality and climate the more state-like properties of mood. For the purpose of this discussion climate is viewed as a temporal manifestation of culture, which is reflected in the shared perceptions of the organization at a discrete point in time (Cox and Cheyne, 1999).

Reviewing 16 studies that proffered definitions of safety climate/culture, Guldenmund (2000) observed that perceptions are more likely to be associated with climate measures, whereas attitudes are considered to be part of culture. However, researches have often failed to make the distinction between these two concepts of safety management and these terms are often used interchangeably. Hence literatures on both safety climate and safety culture are discussed in this section.

One way to make the safety culture more visible is through the use of employee perception surveys, which have been valuable tools for detecting differences in employee attitudes concerning several management practices. Ojanen et al. (1988) suggested that safety performance should be measured on multiple levels, one of them being safety attitudes, in order to determine the real safety level of an organization. They claimed that measuring safety climate can indicate changes in organizational safety behavior and would therefore be useful for evaluating safety programs and suggested that safety climate questionnaire is the only way to measure safety climate in an organization.

2.2 RESEARCH ON SAFETY CULTURE/CLIMATE

In the early 1950s, aspects of psychological climate were found to relate to accident causation in an automotive plant (Keenan et al., 1951). The researchers argued that inter-departmental differences in accident rate might be attributable to differences in psychological climate. The dynamics of group processes have also been considered, and found to influence attitudes towards safety (Lewin, 1958; Likert, 1967). Additionally, a series of Japanese studies over the last 30 years has related the importance of group decision-making to safety and accident reduction in a variety of organizations ranging from a bus company to a shipyard (Misumi, 1989). Brian (1988) placed considerable emphasis on the ways in which attention to attitudinal factors has lead to improvements in the safety performance of a number of US chemical companies; reductions in lost-time injuries were found to be directly attributable to the positive management of safety.

Green (1980) had demonstrated how attitudes towards accidents are influenced by previous experience. He found that frequency of accidents and knowledge of the ways in which accidents happen contribute to the attitude towards them, and may also be instrumental in affecting attitude change. Recognition of potential hazard derives from a safety climate where members of the organization are responsive to safety implementations. A study of 24 US nuclear power plants showed that attitudes, which facilitate pro-active safety interventions, relate not only to improved safety performance but also to higher productivity (Marcus, 1988). Plants in which all employees share attitudes towards safety which permit them to retain control and responsibility for accident prevention have a good safety record and three times fewer human error events than plants in which employees do not share such attitudes.

One of the clearest demonstrations of the relationship between safety attitudes/climate and accident rates was demonstrated in a study carried out at British Steel (Canter and Olearnik, 1989). In this study, all accidents and lost-time accidents at 16 plants of one British Steel site were correlated with attitudes towards various aspects of safety, as measured by a safety attitude question set. Answers to the safety attitude questions were found to predict the level of accidents in any given plant. This showed not only the close links between accidents and attitudes, but also demonstrated the possibility of producing reliable measurement instruments.

Following the work in British Steel, Donald and Canter (1993) attempted to identify the basic constituents of safety attitude using a short question set, and to develop scales from them to demonstrate their relationship to safety performance, in chemical industry. This study revealed 3 facets of safety attitude: people or the organizational roles which make up the safety climate, attitude behavior or aspects of an individual's safety behavior and safety activity or type of safety behavior. The scale was found to have good reliability (above 0.8). The results demonstrated that all the scales except 'safety representatives scale' are negatively correlated to self-reported accident rate at '$p < 0.05$' significance level.

In another study, Bailey (1989) used Minnesota Safety Perception Survey to identify factors that positively contributed to injury reduction within the railroad industry. Both the original study and its extension, which include other industries (Bailey, 1997), showed that in plants that had low injury rates, the employees' perception of management commitment to safety was highly positive. On the other hand, in plants where injury rates were high, the employees' perception of management commitment to safety was low and the major focus of management's safety efforts was on compliance of rules and procedures with limited employee involvement practices. Employees' perception of management's commitment to safety, of fellow employees' participation in safety, and of the effectiveness of education and training on the part of the management have demonstrated a positive impact on safety outcomes (Bailey, 1997).

Simonds and Shafari-Sahrai (1977) analyzed the relationship between injury frequency rates and factors thought to influence injury rates, such as management involvement in the safety effort, workforce characteristics, and physical conditions. They gathered data on the management system of companies, some with high injury rates and others with low injury rates. In studying these matched pairs of companies, the researchers found that in companies where top management is involved in safety, there were lower injury frequency rates.

In a similar study, Cohen (1977) examined critical determinants of a successful industrial safety program and found that, in firms that experienced low injury rates, certain common factors were present. These factors were, strong management commitment to safety as reflected by management's knowledge of the problems, their convictions that high safety standards were attainable and their demonstrated work toward those ends. In addition, Cohen identified extensive formal and informal contacts between workers and management on safety issues and well-established safety training process as factors contributing to low accident rates. In a follow-up study, Smith et al. (1978) found that management's commitment to the safety process was an important factor at low injury rate plants.

In another research, Schneider (1975) studied organizational climates and found that workers formed different "climate" perceptions of their environment. Further research into this area by Payne et al. (1976) suggested that organizational climate would be better used to describe the attitudes and performance of individuals and measuring organizational climate provides a useful tool for managing/changing behavior of employees and organizations.

Zohar (1980) developed the first measure, based on an Israeli sample in 1980 using a 40-item questionnaire covering metal fabrication, chemical, textile and food processing industries. After factor analysis, his final model included 8 dimensions with workers' perceptions of: the importance of safety training, management attitude towards safety, effects of safe conduct on promotion, level of risk at workplace, effects of work pace on safety, status of safety officer, effects of safe conduct on social status and status of safety committee. Analysis of the data in this study supported both hypotheses, namely: (a) Safety climate can be regarded as a characteristic of industrial organizations, and (b) safety climate is related to the general safety level in these organizations.

Brown and Holmes (1986) tried to replicate this factor structure in an American sample using confirmatory factor analysis and found that it is not supported. They arrived at a new set of 3 factors: employees' perceptions of management concern about their well-being, management activity in responding to problems with their well being and their own physical risk. Dedobbeleer and Beland (1991) tested this 3 factor model in construction workers in Canada and found that it was supported by their data, but a 2 factor solution was found superior. The 2 factors were interpreted to be management commitment to safety and workers' involvement in safety.

Glennon (1982) developed a questionnaire on an Australian workforce and found nine climate dimensions, slightly expanding on Zohar's original eight dimensions. He found that determination of an organization's safety climate was dependent on a number of complex issues and there could never be any absolute external standards, as indicated by Zohar (1980).

Seppala (1992) studied the safety climate in Finnish plywood industry, shipyards, factory and building construction industries and indicated that the safety climate was dependent on 4 factors: organizational responsibility, workers' concern about safety, workers' indifference with regard to safety and the level of safety precautions in the company. Cox and Cox (1991) studied the employees' attitude in organizations, which manufactured industrial gas across Europe. Factor analysis of the data collected suggested 5 factors: personal skepticism, individual responsibility, the safeness of work environment, the effectiveness of arrangements for safety and personal immunity. In both cases, the scales were found to be reliable and valid.

The study of Niskanen (1994) on road construction workers in Finland found two separate 4 factor solutions for workmen and for supervisors from factor analysis. For workmen the factors obtained were: attitude towards safety in organization, changes in the work demands, safety as part of productive work and appreciation of the work. For supervisors, the first 3 factors remained the same and the fourth was value of work. Neither the reliability nor the validity of the questionnaire was tested in this study and hence this is considered as an exploratory one only.

Coyle et al. (1995) in their study on two different health care and social service organizations revealed two different factor sets and claimed that safety climate factors are not stable across organizations. Only factor analysis was attempted in this study and no statistical tests were conducted for examine reliability or relationship with safety performance.

Williamson et al. (1997) studied the safety climate in a wide variety of types of jobs in Australia by measuring attitudes, perceptions and awareness of safety and revealed 5 factors: personal motivation for safe behavior, positive safety practice, fatalism, risk justification and optimism. Validity of the factor structure of the scale was examined using responses to two of the additional questions in the original item pool. Even though reliability was not assessed and validation was insufficient, items covering both attitudinal and employees' perceptions of workplace characteristics resulted in a broader factor structure compared with those identified in a number of studies (e.g. Zohar, 1980; Brown and Holmes, 1986; Dedobbeleer and Beland, 1991).

Diaz and Cabrera (1997) conducted a survey in three airport companies in Spain using an instrument designed from previous studies and obtained six factors on exploratory factor analysis (Company policies towards safety, Emphasis on productivity versus safety, Group attitudes towards safety, Specific strategies of prevention, Safety level perceived in the airport and Safety level perceived on the job). The reliability of the instrument was found high and the factors together explained 61 % of the total variance. Analysis revealed significant differences in the safety level in the companies and was found to discriminate between high and low accident rate organizations. Various analysis were also conducted to determine the possible relationships between the independent variables such as, hierarchical position, education level, time in the company, age and whether working on a ramp or not.

Varonen and Mattila (2000) studied the structure of safety climate in wood processing industries in Finland and found that organizational responsibility, workers' safety attitudes, safety supervision and company safety precautions accounted for 40% of the total variance. The factors were found to be reliable and showed negative correlation with accident rates.

Cox and Cheyne (2000) formulated a safety assessment questionnaire for offshore environment, based on established common themes, comparison with instruments in other industrial sectors, and review of constructs identified in the focus group discussions. This consisted of 47 items covering areas of Management commitment, Communication, Priority of safety, Safety rules and procedures, Supportive environment, Involvement, Personal priorities and need for safety, Personal appreciation of risk and Work environment. Data collected from 350 employees from three offshore installations were subjected to a series of statistical tests including confirmatory factor analysis (CFA), internal-scale consistency and alternate forms reliability tests. Comparative Fit Index (CFI) obtained was 0.85, which is below the acceptable value of 0.9. Measures of internal reliability for each of the factors were found to be good with only "Personal appreciation of risk" falling below 0.6. Overall, the instrument was found to be reasonably valid and reliable.

Glendon and Litherland (2001) studied the safety climate factor structure among road construction and maintenance workers in Australia. The instrument used was a modified version of "Safety Climate Questionnaire" developed by the same authors in a previous study. Principal component factor analysis yielded the following six factors, which explained 69.3% of the total variance: Communication and support, adequacy of procedures, work pressure, personal protective equipment, relationships and safety rules. Multiple regression analysis with behavioral measures (safety performance) as dependent variable and safety climate factors as independent variables did not show any positive relationship between them. This result contradicted the limited previous research on relationship between safety climate and safety performance (e.g. Zohar, 1980; Glennon, 1982; Lee and Harrison, 2000).

Mearns et al. (2003) conducted a safety climate survey on 13 oil and gas installations in United Kingdom using "Offshore Safety Questionnaire-OSQ" developed from previous research (Rundmo, 1994,1997; Mearns et al., 1997,1998). The measurement scales used were, Satisfaction with safety activities, Involvement in health and safety, Communication about health and safety, Perceived supervisor competence, Perceived management commitment to safety, Frequency of general unsafe behaviour, Frequency of unsafe behaviour under incentives, Safety policy knowledge, Job satisfaction, Written rules and procedures and Willingness to report accidents. Analysis of data revealed that supervisors provided more favourable scores than other respondents on most of the scales. Differences between installations in their accident rates were reflected in differences in safety climate scores for both accident and non-accident groups. Management commitment emerged as a key predictor of accident proportion in this study.

Carder and Ragan (2003) used modified version of "Minnesota Safety Perception Survey" questionnaire to study over 50 chemical plants in United States of America and obtained a 6 factor model after factor analysis. Interestingly, the factors appeared to be fundamental components (Management demonstration of commitment to safety, Education and knowledge of the workforce, Effectiveness of the supervisory process, Employee involvement and commitment, Drugs and alcohol and Off-the-job safety). The instrument was found reliable and validation effort was successful. Those sites with higher survey scores were found to have lower accident rates.

Silva et al. (2004) designed an "Organizational Safety Climate Inventory" comprising of four dimensions (shared perceptions about safety values, norms, beliefs, practices and procedures) and 78 items and conducted a survey in 15 Portuguese organizations in different sectors (chemical industry, electricity industry, public administration, and health). Reliability was found to be good (above 0.77) for all scales and confirmatory factor analysis testified that the model fitted well the data. The scale scores correlated well with accident data proving its predictive validity.

2.3 RESEARCH ON SAFETY MANAGEMENT

The typically large number of accidents due to safety management failings (Kawka and Kirchsteiger, 1999; Reason, 1998) justifies the development of audit tools for ensuring effective safety management practices (Hurst et al., 1996; Hudson et al., 1994; Mitchison and Papadakis, 1999). Examination of safety management practices should be considered an adjunct to the assessment of safety climate within an organization. In hazardous environments, such as chemical/process industries, it is essential to audit safety climate as well as safety management practices.

Safety management may be seen as the process whereby "informed decisions are taken to meet accepted safety criteria" and thus, safety management could be regarded as "the management process to achieve a state of freedom from unacceptable risks or harm" (Cox and Tait, 1991). Safety management is carried out via the organization's safety management system, including various safety management practices, which acts as a system of control over work activities and work methods (Kennedy and Kirwan, 1998). Safety management as an approach is relatively mature, and a number of guidelines on the implementation and operation of effective management systems for health and safety have been issued by regulating governmental agencies in developed countries. These have often been linked to pre-existing standards on quality systems and management. In developing countries, managements adopt various safety management practices voluntarily for ensuring health and safety of their employees.

Researches have revealed that favourable safety climate is essential for safe operation. What is less clear are which antecedent factors promote a favourable safety climate. The issue is important because of the implications of intervention strategies. Research has focused on supervisors as role models for instilling safety awareness and supporting safe behaviour (Fleming et al., 1996; Mattila et al., 1994). Involvement of the workforce in safety decision-making has also received attention (Simard and Marchand, 1994). Both of these concepts naturally lead to a consideration of the safety philosophy of upper management and the safety management system of the organization. Hofmann et al. (1995) label the individual attitudes and behaviours discernible in safety climate as the micro-elements of an organization, which themselves are determined by macro-elements of the safety management system and practices. In this sense management attitudes and behaviour toward safety permeate down through the organization to the workforce.

Safety management relates to the actual practices, roles and functions associated with remaining safe (Kirwan, 1998). It is therefore more than a 'paper system' of policies and procedures. An audit of the official safety management system may begin and end with an analysis of what is contained in the paperwork but it therefore says little about how the system is being enacted in the field. Such an analysis identifies what an organization should be doing to protect its workers, the public and environment from harm but it does not reveal what is actually happening in the worksite and whether or not people and environment are being protected and adverse events are not occurring.

There have been numerous attempts to isolate specific safety management practices that predict safety performance (i.e. accidents and incidents). Some of the earliest studies identified common features of companies with high safety performance, but failed to include controls with low performance. Cohen (1977) reviewed four such studies, and in at least three cases the following factors were common to the sample: safety officers held high rank; management showed personal involvement in safety activities; training was superior for new employees and conducted at regular intervals for existing employees; specially designed posters were used to identify potential hazards; there were well defined procedures for promotion and job placement; daily communication between workers and supervisors about health and safety was the norm and site inspections were frequent.

In contrast, Shafai-Sahrai (1971) examined 11 matched pairs of companies conducting on-site interviews and site inspections at each. Organizations with lower accident rates were characterized by: the presence of upper managers who were personally involved in safety activities; prioritization of safety in meetings and in decisions concerning work practices; and thorough investigation of incidents.

Cohen et al. (1975) and Smith et al. (1975) examined 42 matched pairs of companies. Those with lower accident rates were characterized by: the presence of safety officers with high rank; the presence of upper managers who were personally involved in safety activities; training for new employees, with frequent retraining for existing employees; and more pervasive lines of informal communication between higher management and workers, e.g. daily communication between supervisors and their teams. Shannon et al. (1996) conducted a postal survey of over 400 manufacturing companies, each having at least 50 employees. The defining features of organizations with lower rates of lost time injury included: managers who perceived more participation in decision-making by the workforce and more harmonious management-worker relations; encouragement of long-term career commitment; provision of long and short term disability plans; definition of health and safety responsibilities in every manager's job description; performance appraisals with topics related to health and safety; and more frequent attendance of senior managers at health and safety meetings.

Vredenburgh (2002) studied the level of safety management practices in hospital employees with the help of a questionnaire survey. Participants were risk managers from 62 hospitals located in several states in the United States. This study examined the degree to which six management practices frequently included in safety programmes (Management commitment, Rewards, Communication and feedback, Hiring practices, Training and Participation) contributed to safe work environment for hospital employees. The dependent variable was injury rates collected from the hospital records. Linear multiple regression analysis was used to assess the predictive capacity of management practices of injury rates. The only management practice that individually predicted injury rates was 'Hiring practices'. This was in tune with the findings of Eckhardt (1996) and Turner (1991) who observed that, consideration of safety performance in selection of employees helps to reduce injury rates.

An exploratory factor analysis was conducted to verify that the management practices items (predictors) loaded into the expected subscales (six safety management practices). Even though six factors were obtained, explaining 69% of the variance in the data, the items in the factors did not correspond to those in the six safety management practices.

Mearns et al. (2003) devised an audit tool, "Safety Management Questionnaire -SMQ" to assess safety management practices in 8 oil and gas installations in UK. The following indicators suitable for offshore environment were selected from previous studies (Fuller, 1999; Miller and Cox, 1997; Blackmore, 1997; HSE, 1997): Health and safety policy, Organizing for health and safety, Management commitment, Workforce involvement, Health promotion and surveillance and Health and safety auditing. This data on safety management practices were collected from senior management in two successive years. Favourable total SMQ scores were found to be associated with lower rates of lost time injuries in each year.

Some researchers have tried to explore the mechanisms by which safety management practices influence safety behaviours of individuals in organizations. Smith-Crowe et al. (2003) found that safety management practices, especially safety training, moderate the relationship between safety knowledge and safety performance. Neal et al. (2000) studied the relationships between antecedents, determinants and components of safety performance using structural equation modelling procedures among Australian hospital workers and revealed that, safety knowledge and safety motivation individually predict both safety compliance and safety participation. Safety management practices were found to predict both safety knowledge and safety motivation. The mediating effect of safety knowledge and safety motivation on the relationship between safety management practices and safety performance were also observed in this study.

In a large-scale study in 13 companies operating in manufacturing sector in United Kingdom using questionnaires and interviews, Cox et al. (1998) attempted to model commitment to safety in terms of management actions for safety, quality of safety training and personal actions for safety. Structural model showed that 'management actions for safety' and 'quality of safety training' predicted 'appraisal of commitment to safety' while 'personal actions for safety' did not. However, the effect of 'management actions for safety' was much greater than that of 'quality of safety training'. 'Management actions for safety' predicted 'personal actions for safety', while there was a reciprocal relationship between 'management actions for safety' and 'quality of safety training'. 'Personal actions for safety' did not, in part, mediate the relationship between 'management actions for safety' and 'quality of safety training' on one hand and 'appraisal of commitment to safety' on the other.

2.4 OBSERVATIONS FROM LITERATURE REVIEW AND MOTIVATION FOR CURRENT RESEARCH WORK

2.4.1 Observations from literature review

From the literature review presented above, it is evident that the research literature on safety culture/climate leaves scope for a lot of additional research. Many researchers have studied different types of industries and factor analysis techniques have been used to determine the factors. Reliability of the factors obtained and the relationship between these factors and accident rates by correlation analysis has also been presented in some of the researches. However, the following aspects are worth noting from these studies:

- Although most of the researches reported are conducted according to the well-accepted methodology of social scientific research, little consensus has been reached on the different aspects commonly associated with safety culture/climate within this scientific discipline. Researchers have used different questionnaires resulting in different factor structures. Questionnaires that have been used were naturally influenced by the authors' perceptions of what questions were "important";

- While the importance of the concept of safety climate or culture is stressed by most authors, very few have attempted to support their claim by reporting an indication of its construct validity, unidimensionality or predictive validity. Most efforts have not progressed beyond the stage of face validity;
- It is found that "Management actions for safety" emerged as the principal factor in many studies. Since this factor contains the various safety management practices adopted by the managements, assessment of level or deficiencies in each safety management practice become difficult from these studies;
- Most of the studies in safety culture/climate have been reported from developed countries where different safety management practices are already implemented in industries. There is no sufficient research evidence from developing countries like India where safety management has gained attention only recently.

A thorough survey of the literature review presented in the previous sections reveals that only a few studies have been carried out with respect to the implementation of safety management practices in industries. Most of the studies are either theoretical in nature or case studies. Proper identification of the critical safety management practices is essential for successful implementation of safety management and this is not reported in any of the studies. However, researchers have studied the difference in level of different safety management practices in high and low accident rate companies to explore their characteristics. The predictive capacity of safety management practices on safety outcomes was investigated by Vredenburgh (2002), but the safety management practices chosen was not empirically validated.

Neal et al. (2000) explored the relationship between safety management practices and determinants (safety knowledge and safety motivation) and components (safety compliance and safety participation) of safety performance using structural equation modelling. Since this study was carried out using summated score of safety management practices, individual effects of various safety management practices on determinants and components of safety performance still remain unexplored.

There is no research evidence examining the predictive capacity of safety management practices on determinants of safety performance and also, determinants of safety performance on components of safety performance. Comparison of level of safety management practices, determinants and components of safety performance in industries classified on the basis of management system certifications such as ISO 9001, OHSAS 18001 and ISRS was not found in literature review. Another research area that was found unexplored was related to the investigation of relationship between personal attributes of employees (such as age, qualification, years of experience, accident history and job category) and determinants and components of safety performance.

Since Indian industries were adopting traditional safety management techniques till recently, safety climate studies to determine the underlying factors and their effects on safety performance outcomes in all types of industries are yet to begin. This attempt in that direction is expected to contribute toward filling that huge gap in literature.

2.4.2 Motivating factors for the present research

While considerable research has been reported on the topic of safety management in industries from various parts of the world, there is scarcity of literature from India. The survey of literature on safety management reveals that the implementation of various safety management practices can contribute towards reducing accidents and injuries, thereby improving overall performance of an organization. However, empirical research on this topic seems to be meagre in the case of Indian industries. Therefore, it is expected that a clear understanding of the critical safety management practices would help in the implementation of safety management systems.

It appears that an empirical investigation of the relationship between the safety management practices and the determinants and components of safety performance is necessary, since the decision makers need to have evidence and scientific explanations to support their decisions. Literature review revealed that enough such studies have not been reported not only from India, but also from developed countries.

Investigation into the level of safety management practices in organizations with low, medium and high accident rates can reveal which safety management practice contributes more in accident prevention. Similar study in organizations with different management system certifications can answer the question: "Which management system certification is best suited in Indian industries for better safety performance?".

Study on the relationship among personal attributes of employees and determinants and components of safety performance may reveal "whom to target" while designing improvement strategies and programmes. Structural equation modelling of safety performance using management practices, determinants and components of safety performance can reveal the strengths of their relationships which can finally help the decision makers in designing proper safety intervention programmes.

Measuring safety climate can be referred as taking the "safety temperature" of an organization since it comprise a summary of employee perceptions of a range of safety issues. Hence, it would be appropriate to understand the safety climate factors in various organizations and their relationships with accidents and management system certifications. It will also be beneficial to compare the safety climate structure in different types of industries to design most appropriate safety intervention programmes. It is evident from literature review that such attempts have not been done so far in Indian industries, and hence an attempt in this direction would be highly instrumental in motivating employees and demonstrating the commitment of management for the health and safety of employees.

CHAPTER 3

CRITICAL SAFETY MANAGEMENT PRACTICES IN INDUSTRIES

In Section 3.1 critical safety management practices in industries are identified from the employees' perspective, and this is followed by a detailed discussion on the critical safety management practices. Section 3.2 furnishes a detailed discussion on the procedure for the empirical validation of the instrument to measure the critical safety management practices in industries. Section 3.3 empirically analyzes the relationship among the different safety management practices identified. Section 3.4 summarizes all the findings and inferences.

The importance of safety in human life is spreading to all walks of life and all types of organizations, making *Safety Management* a potential area of research. The primary objective of the study was to identify the critical safety management practices in industries from the employees' perspective, based on an empirical analysis. Such an empirical study demands a rigorous research methodology with reliable and valid instruments. This can be achieved only by measuring the perceptions of employees in the industries. A survey using questionnaire is widely acknowledged as an effective tool for assessing the perceptions of individuals on a particular subject. A study using such an instrument can enhance the process of theory building in industrial safety management; and the findings of the study can be effectively used by practitioners for the betterment of safety management programmes in organizations.

3.1 CRITICAL DIMENSIONS OF SAFETY MANAGEMENT

The following critical safety management practices have been identified from literature survey and through discussions with the safety professionals and safety managers from various industrial units in Kerala:

1. Management Commitment (MC)
2. Safety Training (ST)
3. Worker Involvement in Safety (WI)

4. Safety Communication and Feedback (SC)
5. Safety Rules and Procedures (SR)
6. Safety Promotion Policies (SP)

A detailed discussion on these safety management practices is presented below.

3.1.1 Management Commitment

According to Deming (1986), top management is responsible for most of the safety problems because they control the assignment of resources, establish and implement the methods of work, develop the policies, and so forth. For these reasons, each management should be the lone sponsor of their own particular results (Sznaider, 1998). Safety improvement of the system is the responsibility of top management, though an important role is played by workers and team members in order to achieve the overall objectives of the company.

In a review of early research, Cohen (1977) reveals that management commitment to safety was a consistent factor in successful safety programmes, although other factors were also found. In one of the first investigations of safety climate, Zohar (1980) found that management's commitment to safety is a major factor affecting the success of safety programmes in industry and this parameter is capable of discriminating between high and low accident rate organizations. Management commitment remains a key component of contemporary safety climate research (e.g., Flin et al., 1996; Marsh et al., 1998; Cox and Cheyne, 2000). This commitment can manifest itself through management participation in safety committees, consideration of safety in job design, review of pace of work, accident and near-miss incident investigation and follow-up actions, priority assigned for safety, occupational health programmes etc. Investment by the company in these areas fosters perceptions of company commitment and builds worker loyalty in areas such as safety behaviour (Mearns et al. 2003). Employees perceptions will reflect how employees believe that safety is valued in the organization (Neal et al., 2000). In high risk environments like chemical industries, management commitment has been repeatedly highlighted.

In five plants recognized by the National Safety Council for 'no lost working days', all of the plants required advance approval by safety personnel for any changes in the design of the work facilities. In four of the plants, the plant safety director had direct contact with the plant manager on a daily basis (Cohen and Cleveland, 1983). The motivation to perform a job in a safe manner is a function of both the individual's own concern for safety as well as management's expressed concern for safety. Safety commitment of the management must result in an observable activity on the part of the management and must be demonstrated in their behaviour as well as their words (Hofmann et al., 1995).

3.1.2 Safety Training

In order for employees to be active participants in a safety programme, they must receive occupational safety training. Cohen and Jensen (1984) state that, "a well-designed and administered training programme, emphasizing safe work practices and derived from a true assessment of need can be effective in improving on-the-job behaviour. Even better performance can be achieved by following training with a programme based on goal-setting and performance feedback supplemented with informal peer group modelling". Training programme assessment should verify that the safe work practices can be demonstrated to be effective and to endure beyond cessation of performance feedback. According to Cohen and Jensen (1984), there should be a redefinition of group norms sustained through informal influences such as peer modeling of desired behaviours, continued management support of the programme, and a behaviour sampling procedure specifying performance-based criteria.

Individuals, after performing a given task a number of times, develop an automatic "procedure" for its accomplishment. Although committing procedures to written form makes the sequence of operations clear, the problem facing those concerned with safety is ensuring that operators follow the steps contained in the written procedures. Both Kletz (1985) and Reason (1990) conclude that slips will occur, but suggest that these slips can be minimized through better training, instructions and procedures (Hofmann et al., 1995).

Safety training provides the means for identifying actions leading to accidents. The basic difference between safe employees and those who frequently get hurt is that safe employees can recognize hazards and hazardous actions and understand the consequences. As companies are paying closer attention to both direct and indirect costs of injuries, they are discovering its relationship with quality improvement efforts. Incorporating quality management principles integrates safety and health into other aspects of the business (such as workers' compensation). To improve the quality of safety and health for all employees, organizations should institute a systematic, comprehensive safety and health training programme for new employees, provide a mentor for these employees, and use a buddy system to help orient new employees in the safety and health and quality systems. They should also institute a system of continual re-education and retraining of employees in current safety and health issues (Roughton, 1993).

Several issues affect the perception of risk levels and should be understood when training employees in occupational safety. Consistent with several studies in risk perception, Vredenburgh and Cohen (1995a) found that women perceived a higher level of risk than did men. One's culture or ethnicity may also affect how he or she perceives hazards. In comparing the perceived risk associated with various activities (work and recreation-related), there was a difference in the level of risk reported by the respondents depending on their identified cultural group. Wogalter et al. (1991) found that two factors influence the perception of danger: the severity of potential injury and whether the product was technologically complex. People tend not to use the *likelihood* of injury in their judgments of product safety; rather, the *severity* of injury plays the foremost role in decisions to read warnings and act cautiously (Young et al., 1990). Vredenburgh and Cohen (1995b) found that the level of perceived danger increased compliance to warnings and instructions; therefore, it is critical that all employees have a thorough understanding of the hazards associated with their workplace.

The studies of Lee (1998), Ostrom et al. (1993), Tinmannsvik (2003), Cohen et al. (1975), Smith et al. (1975) and Zohar (1980) have found that those companies with lower accident rate were characterized by good safety training to employees.

3.1.3 Worker Involvement in Safety

Worker involvement is a behavioural-oriented technique that involves individuals or groups in the upward communication flow and decision-making process within the organization. The amount of participation can range from no participation where the supervisor makes all decisions, to full participation where everyone connected with or affected by the decision is involved (Vredenburgh, 2002).

Employees close to the work are recognized as often being the best qualified to make suggestions about improvements. Participative managers will solicit opinions from other individuals or groups before making final decisions, especially for those that affect the employees. The empowerment of employees is both a management style and attitude. Empowering workers provides them with authority, responsibility and accountability for required decisions and ensures that both employees and management are involved in setting goals and objectives. It induces employees to do their best work as individuals and as a team, while relieving the manager to plan, monitor, lead and mentor (Cohen and Cleveland, 1983).

In the United States, employee involvement has tended to focus on greater personal influence on the shop floor and on a greater role in the decision-making involving the employees' daily work experience (Cohen and Cleveland, 1983). A small number of studies attempting to use worker participation in hazard management were implemented in design, manufacturing, or other heavy industries where myriad physical hazards were readily apparent. Only one recent study has documented this type of programme being introduced into a service industry, such as health care delivery, despite the fact that the hospital environment has a high risk of injuries and illness (NIOSH Report, 1983).

Safety committees have become a standard feature of workplace safety programmes; however, committees themselves do not necessarily mean effective employee involvement. Committees must be given real power to implement change. The members must be in positions where they can have a positive impact on the committee's work (such as production and engineering supervisors) and must be well trained. One such programme took place in the 1980's at the San Onofre nuclear power plant construction site north of San Diego, California. It had a joint labour-management committee overseeing safety and health at the site, including inspection functions ordinarily carried out by the State Division of Occupational Safety and Health Administration (OSHA). This programme was successful in reducing accident rates and improving labour-management cooperation (Cohen, 1983).

Worker involvement has been reported as a decisive factor in safety management by Lee (1998), Rundmo (1994), Dedobbeleer and Beland (1991), Shannon et al.(1996), Cox and Cheyne (2000) and Vredenburgh (2002).

3.1.4 Safety Communication and feedback

One way an organization transmits its culture to employees is by feedback. Employees learn to associate their level of performance with its consequence. When managers provide positive feedback, they reinforce a behaviour; in contrast, negative feedback reduces frequency of future behaviour. When employees define the range of appropriate behaviour, based on their experience in their organization, this leads to culture (Thompson and Luthans, 1990).

The role of feedback concerning employees' performance is critical because behaviours resulting in industrial accidents are not typically new occurrences. Their causes are deeply rooted in past minor incidents, where damage was insignificant and workers and bystanders were not injured (Kletz, 1993). Regular feedback on performance can be communicated to employees through posted charts and a review of behavioural data in safety meetings (Roughton, 1993).

According to Pidgeon (1991), "The incubation model of disasters suggests that near-misses will often differ from actual disasters only by the absence of the final trigger event and the intervention of chance. Near-miss incidents can often be interpreted, and not just with the benefit of hindsight, as warning signals". In some contexts, such as the aviation industry (Hall and Hecht, 1979), a high premium is placed on the analysis and dissemination of incident data obtained on a "no-fault" reporting basis. In the five National Safety Council award-winning plants, the organizations had some form of employee hazard identification system in which they were encouraged to report hazards to management (Cohen and Cleveland, 1983). In order to encourage communication, it is important not to blame employees when accidents occur. As managers have gained experience with the techniques used to improve quality, they have learned the importance of improving the process of production. Many managers now work to solve production problems upstream rather than inspecting for defects downstream (Roughton, 1993).

Consistent and forthright communication is an essential characteristic of any strong organization. Good communication leads to trust, which is a fundamental element of strength. In order for organizations to foster a climate where employees are alert to hazards, they must have an appreciation of the employees' and organizations' tendency to conceal and distort significant available information (Pidgeon, 1991). In order to influence safety practices, feedback must be provided to the employees who are capable of using it. It needs to be given to those working at the point in the process where their behaviour can effectively influence outcomes. People cannot behave in a safety-conscious manner unless they have the authority to change their own actions to improve their work conditions. It is illogical to ask employees to be careful if they do not have the power or discretion to avoid hazards (Turner, 1991). Laws (1996) writes, "motivation is no big deal, you can motivate a baboon. But if you don't back that motivation with tools, skills, training, counseling and leadership, then all you have is a highly frustrated, motivated ape that cannot get the job done".

Communicating hazard information is not always adequate. After discounting situations in which employees ignored safety instructions because the message was ineffectively communicated or was misunderstood, there remains a large group of cases in which the operator apparently had a choice and chose the dangerous alternative. It is apparent that the cost of compliance can influence behaviour. Zeitlin (1994) found that the decision to obey safety instructions was mediated by user experience with the hazard and by the sensitization to safety issues. Extending these results to the workplace suggests that if workers place a high value on their time, convenience, self-image, status among peers and other factors, and if they estimate the probability of being injured due to ignoring a safety instruction as sufficiently low, then it is likely that the instruction will be disregarded despite the fact that it was clearly presented.

Communication of health and safety issues to the workforce has been viewed as a key stage of organizational learning that proceeds from accidents/near miss investigations, safety audits or changes to procedures (Mearns et al., 2003). It is a key aspect of the safety management tool of Hurst et al. (1996) as well as the Health and Safety Executive (HSE) safety climate survey tool. Lee (1998) lists communication in his nine characteristics of low accident plants, and it emerges as an important factor in the success of safety programmes (Harper et al., 1997; Tan-Wilhelm et al., 2000; Vredenburgh, 2002).

3.1.5 Safety Rules and Procedures

Manufacturers of equipment and machinery conduct safety audits of their product as a part of product safety management programme during the design and manufacture (Hagan et al., 2001). This results in establishing the correct and safe operating and maintenance procedure for the equipment and these details will be supplied to the user on purchasing the same. Managers, supervisors and workers will be trained by the manufacturer to use the equipment safely and correctly. In addition to new equipment and machinery, all activities including operation and maintenance of all machinery and equipment will have documented safe procedures (e.g., work permit systems, use of personal protective equipment).

Every country has rules and regulations to safeguard the health and safety of employees. In India, 'The Factories Act, 1948' is the guiding document and various states have made Factories Rules based on the above central Act (e.g., 'The Kerala Factories Rules, 1957'). Every organization has to prepare a 'Safety Manual' based on these documents, covering the various activities employed in the organization. To what extent these are practised in reality depends on the supervisors or first line officers who supervise the work.

It is reported that, only if the supervisors are given the responsibility of workers' safety, with authority to stop work for safety lapses and award punishments to workers for non-compliance, the required priority will be achieved (Zohar, 1980; Hansen, 1993). Hagan et al. (2001) point out that safety of employees should not be considered as the botheration of the safety officers, but responsibility of all those who manage work and proper delegation of authority should accompany responsibility.

In spite of all efforts, workers tend to deviate from correct and safe operating and maintenance procedures due to reasons such as work pace, over-experience, indifferent attitude, over-confidence etc. Enforcement of safety rules and procedures by supervisors achieve significance in such situations. Glendon and Litherland (2001) reported this as reliable after analyzing the data collected from construction workers. Lee (1995), Donald (1995), Cox and Cheyne (2000), Flin et al. (2000) and Silva et al. (2004) considered safety rules and procedures as a factor influencing safety performance of employees in their studies.

3.1.6 Safety Promotion Policies

Activities from the management side to promote safe behaviour include conducting recreational activities at relevant occasions to inculcate safety awareness among employees, giving rewards/incentives for notable contributions to improve or promote safety, giving safety records of employees due weightage in job promotions etc. The use of incentives, awards and recognition to motivate employees to perform safely is an accepted feature of both organization behaviour management and total quality management models (Hagan et al., 2001). They can add interest to an established hazard control programme which could enhance self-protection action on the part of the workforce (Cohen et al., 1979).

Individuals are moved to behave in ways that lead to desired consequences; they will modify their behaviour to conform to a cultural norm if it is perceived that compliance will lead to a desirable outcome. Culture is learned through a connection that is made between behaviours and consequences. Thompson and Luthans (1990) state, "Organizational culture formation, maintenance, and change occur in an environment where there are multiple reinforcements and reinforcing agents . . . Changing the organization involves the identification of the various reinforcing agents so that an understanding of their effects on the change process might be determined".

Incentives are being employed as a motivational tool in virtually all areas of business and industry; these include incentive programmes specifically designed to improve safety. It is reported that reward system can be used to reinforce employees who call attention to safety problems and those who are innovative in finding ways to locate and assess and remove workplace hazards (Ostrom et al., 1993).

Laws (1996) has reported that, when the city of Port Lavaca, Texas implemented a new reward system, accidents almost immediately dropped by more than half. Port Lavaca based its incentives on a full year's behaviour. Employees were required to attend safety meetings and submit reports that identified potential hazards. The city took care to ensure that its incentive system was easy for the employees to understand.

As with any policy, the effort to develop a strong safety culture is unlikely to be effective if the organization is not reinforcing the desired behaviours (or is rewarding inconsistent behaviours such as speed or production rates). A well-designed incentive programme offers recognition, which can help modify behaviour. According to Vredenburgh (2002), a key characteristic of a successful incentive programme is that it receives a high level of visibility within the organization. Participants must be able to comprehend what the incentive programme is designed to accomplish and they must know how their performance will be measured (Halloran, 1996). Simply distributing prizes and money without pairing them with a clear, consistent set of contingencies reduces the potential to achieve the desired outcome; it may even increase the undesired behaviour – more accidents (Swearington, 1996).

A correctly designed safety-incentive programme rewards the reporting of a hazard or an unsafe act that leads to an injury while giving bonuses for fewer lost-time accidents. A safety incentive programme must be part of a campaign that runs parallel to safety education and training. It must be directed at the prevention of accidents, not punishment after an accident occurs (Peavey, 1995). Informational (feedback, self-recording), social (praise, recognition), and tangible reinforcers (trading stamps, cash bonuses) have been used as well as non-monetary privileges (Komaki et al., 1978).

3.2 DEVELOPMENT OF AN INSTRUMENT FOR THE MEASUREMENT OF CRITICAL SAFETY MANAGEMENT PRACTICES AND ITS EMPIRICAL VALIDATION

3.2.1 Methodology

The primary objective of this study was to develop an instrument for the measurement of the six safety management practices identified from employees' perspective based on an empirical analysis. Such an empirical study demands a rigorous research methodology with reliability and validity analysis so that the findings can be effectively used by practitioners. A measurement model has been designed for each safety management practice, and confirmatory factor analysis (CFA) has been run for all factors for checking convergent validity, unidimensionality and reliability of the factors. Statistical programs SPSS 10 and AMOS 4 were used for these analyses.

3.2.2 Development of an instrument for measurement of critical safety management practices

Since there has been no comprehensive prior instrument available to measure the critical safety management practices in industries from the viewpoint of the employees (especially in India), an instrument has been developed in the current study. The instrument developed is based on an exhaustive survey of literature, and a pilot study among the employees and safety professionals of Major Accident Hazard (MAH) industries in Kerala, so that the theoretical and conceptual subtlety of a factor could be properly explained and critical dimensions of each factor could be identified. Various steps involved in the development and validation of the measurement scale are shown in the flowchart in Figure 3.1.

From a review of related literature and theory, a 44-item questionnaire covering areas of Management commitment, Safety training, Workers involvement, Safety communication and feedback, Safety rules and procedures and Safety promotion policies was prepared. The items included were those safety management characteristics that are found to discriminate between high versus low accident-rate organizations. The content validity and face validity of the instrument have been assured in the initial stages of questionnaire

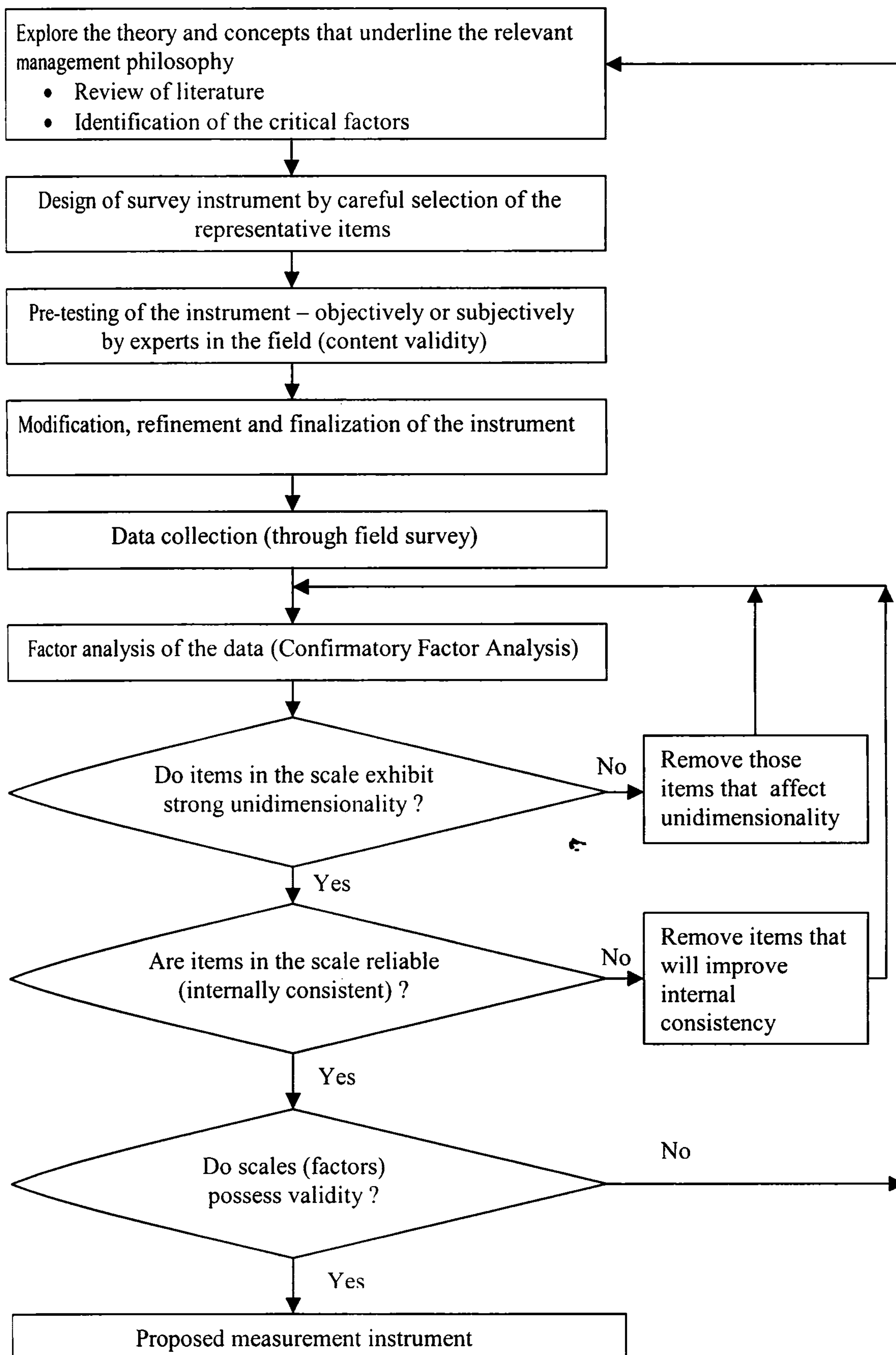

Fig. 3.1 **Development and validation of the instrument**

design and development (Section 3.2.4 gives more details of validity analysis of the proposed instrument). A pilot survey was conducted on a selected sample of 100 workers from five industrial units to get feedback about the clarity of items. The instrument has been refined based on findings of the pilot study, and based on the comments and suggestions of the experts. Subsequently, some of the negatively worded items were changed to positive for simplicity.

The final questionnaire contained 34 items and it was decided to give the questions in English as well as the local language Malayalam. The respondents were asked to give their preference on a 5 point Likert scale (strongly disagree, disagree, neither disagree nor agree, agree and strongly agree) in order to evaluate the subject's agreement with each item. 26 items were phrased positively and 8 items negatively so that strong agreement in the former and strong disagreement in the latter resulted in a higher score in favour of safety for that item. The four-page questionnaire ready for administration consisted of two parts. Ten demographic questions about the name of the company, department, designation, qualification, age, sex, number of years of experience, accident history, number of accidents in 2002 while working in this company which resulted in at least two lost working days as per 'Factories Act, 1948' and number of working days lost due to above accidents in 2002 constituted the first part. The statements related to safety formed the second part. Space was provided beside each statement to mark the preference in the five point Likert scale. To maintain anonymity, no name, badge number or signature was required in the questionnaire.

The questions were jumbled and arranged in a random order in the questionnaire. The full instrument along with the request letter, demographic section and questionnaire section is presented in Appendix.

3.2.3 Sampling and data collection

Eight large chemical industrial units in Kerala were selected for questionnaire administration. All factories had a worker population of 400-800 with separate safety departments. From the previous accident records submitted to the government, it was observed that two of them had high accident rates, four moderate and two low accident rates. After getting permission from the respective managements, the questionnaire was distributed personally to all workers present in the general shift and the morning shift (8 a.m. - 4 p.m.). The participants included workmen and supervisory staff. The researcher explained the purpose of the study while meeting the workers during the tea or lunch break and spent some time with them to clear doubts if any. Completed questionnaires were personally collected from the participants in the evening. The data collection was completed in 6 months and a total of 1806 completed forms were received. Out of this 1566 were from workmen category and 240 from supervisory level first line officers. The number of questionnaires distributed and returned from the eight industrial units with percentage response rate is shown in Table 3.1.

Table 3.1 Sample size and response rate.

Org	No. given	No. returned	Response %
1	342	224	65
2	510	373	73
3	368	243	66
4	231	168	73
5	280	205	73
6	225	171	76
7	245	168	69
8	335	255	76
Total	2536	1806	71

The reason behind opting for a large sample like this was that a smaller sample selection from various departments in each industrial unit was looked upon with apprehension by the workers since the matter was related to statutory requirements of safety of workers. They feared that if the data collected by the researcher is given to the management for any reason, the top management will be able to identify each respondent and his answers that might have gone against the interests of the company, and may finally result in victimization or harassment of those employees. A first attempt for a smaller sample selection in the first organization met with failure, as the workers were reluctant to fill the questionnaire due to these reasons. The actual reason was identified after discussions with the trade union leaders. Henceforth it was decided to give the questionnaire to all eligible respondents present during daytime.

3.2.4 Validity analysis

Validity is defined as the extent to which any measuring instrument measures what it is intended to measure (Carmines and Zeller, 1990). Different validity terms are used to illustrate the various aspects of validity. The comprehensive list of validity types that are mentioned in textbooks and research literature includes face, content, convergent, discriminant and criterion-related validity. The proposed instrument has been tested for validity, so that it could be used for meaningful analysis. The three aspects of validity, namely content validity, face validity and convergent validity, have been tested as explained below.

3.2.4.1 Content validity

Content validity of an instrument refers to the degree to which it provides an adequate depiction of the conceptual domain that it is designed to cover (Hair et al., 1998). In the case of content validity, the evidence is subjective and logical, rather than statistical. Establishment of content validity warrants sound logic, good intuitive skills and high perseverance on the part of the instrument designer (Kaplan and Scauzzo, 1993). Content validity can be ensured if the items representing the various constructs of an instrument are substantiated by a comprehensive review of the relevant literature (Bohrnstedt, 1983). The present instrument has been developed on the basis of a detailed review and analysis of the prescriptive, conceptual, practitioner and empirical literature, so as to ensure the content validity.

3.2.4.2 Face validity

Generally, a measure is considered to have 'face validity' if the items are reasonably related to the perceived purpose of the measure (Kaplan and Scauzzo, 1993). Face validity is the subjective assessment of the correspondence between the individual items and the concept through rating by expert judges (Hair et al., 1998). In face validity, one looks at the measure and judges whether it seems a good translation of the construct under study. Face validity is also a subjective and logical measure, similar to content validity.

The face validity can also be established through review of the instrument by experts in the field (Hair et al., 1998). The present questionnaire has been given to five senior safety professionals from industries and five senior professors in management studies. They have been briefed about the purpose of the study and its scope. The experts have been requested to scrutinize the questionnaire and to give their impressions regarding the relevance and contents of the questionnaire. They have also been asked to critically examine the questionnaire, and to give objective feedback and suggestions with regard to comprehensiveness/coverage, redundancy level, consistency and number of items in each variable. After considering each item in detail, necessary changes were made by simplifying, rewording, removing and replacing some of them. In the initial questionnaire, there were 44 items. Based on the feedback from experts, 10 items were dropped and 34 were retained in the questionnaire for the study.

It may be noted that the content validity and face validity have been assured in the initial stages of questionnaire development itself.

3.2.4.3 Convergent validity

The evidence for 'convergent validity' is obtained when a measure correlates well with other measures that are believed to measure the same construct (Kaplan and Scauzzo, 1993). In other words, convergent validity is the degree to which the various approaches to construct measurements are similar to (converge on) other approaches that they theoretically should be similar to (Sureshchander et al., 2001). It can also be seen that each item in a scale is treated as different approach to measure the construct (Ahire et al.,1996). Using confirmatory factor analysis technique, the convergent validity of the questionnaire is checked with the help of a coefficient called Bentler-Bonett Fit Index (NNFI or TLI). A scale with TLI values of 0.9 or above is an indication of strong convergent validity (Bentler and Bonett, 1980). The values of all the measures are summarized in Table 3.2. It can be seen that TLI value for each of the constructs as well as the overall TLI was more than 0.90, thereby demonstrating strong convergent validity for the instrument.

3.2.5 Unidimensionality Analysis

Unidimensionality refers to the existence of a single construct/trait underlying a set of measures (Hair et al., 1998). The most important and fundamental assumption in measurement theory is that a set of items forming an instrument measures just one thing in common. Items within a measure are useful only to the extent they share a common nucleus - the characteristics to be measured (Nunnally, 1978). The concept of 'unidimensionality' helps to represent the value of a scale by a solitary number (Venkataraman, 1989). Removal of items that reduce unidimensionality helps to solve the problems associated with unidimensionality. An instrument can be fine-tuned in this manner.

Individual items in the model are investigated to see how closely they represent the same construct. A Comparative Fit Index (CFI) of 0.9. or above for the model implies that there is strong evidence of unidimensionality (Byrne, 1994). The unidimensionality of the instrument developed in the current study was tested by computing CFI value for all the factors. The results are shown in Table 3.2. It can be seen that CFI value for each of the constructs as well as the overall CFI is more than 0.90, thereby demonstrating strong unidimensionality of the instrument.

Unidimensionality alone, though a necessary condition, is not sufficient by itself to establish the usefulness of a scale. Once unidimensionality is substantiated, its 'statistical reliability' should be assessed before it is subjected to any further validation analysis (Sureshchander et al.,2001). Reliability of a measure determines its ability to yield consistent results (Nunnally, 1978). Even a perfectly unidimensional (and otherwise construct valid) scale would be rendered futile if the resultant aggregate score is ascertained basically by measurement error, with the values of the scores broadly fluctuating over repeated measures (Gerbing and Anderson, 1988).

3.2.6 Reliability Analysis

Reliability of an instrument is defined as the extent to which any measuring instrument yields the same result on repeated trials (Carmines and Zeller, 1990). It is the degree to which the instrument yields a true score of the variable (factor) under consideration. The instrument is not considered as reliable to the extent to which it contains measurement error (Neale and Liebert, 1986).

There are several methods to establish the reliability of a measuring instrument. These include test-retest method, equivalent forms, split-halves method, and internal consistency method. These methods are based on theories such as true and error scores, parallel forms and domain sampling. Of all these methods, the internal consistency method is considered to be the most effective method, especially in field studies. The advantage of this method is that it requires only one administration, and consequently this method is considered to be the most general form of reliability estimation (Sureshchandar et al., 2001). In this method, reliability is operationalized as 'internal consistency', which is the degree of inter-correlation among the items that constitute the scale (Nunnally, 1978). Internal consistency of a set of items thus refers to the homogeneity of the items in a particular scale. The internal consistency is estimated using a reliability coefficient called Cronbach's alpha (α) (Cronbach, 1951). An alpha value of 0.70 or above is considered to be the criterion for demonstrating strong internal consistency of established scales (Nunnally, 1978). In the case of exploratory research, alpha value of 0.60 or above is also considered as significant (Hair et al., 1998).

Table 3.2 Results of Confirmatory Factor Analysis: Unidimensionality, Convergent Validity and Reliability coefficients for safety management practices.

Sl No	Critical Factors of Safety Management	No.of items	Comparative Fit Index (CFI)	Cronbach's Alpha (α)	Tucker-Lewis Fit Index (TLI)
1	Management Commitment (MC)	8	0.963	0.863	0.959
2	Safety Training (ST)	5	0.993	0.817	0.991
3	Worker Involvement in Safety (WI)	4	0.953	0.692	0.981
4	Safety Communication and Feedback (SC)	4	0.980	0.704	0.978
5	Safety Rules and Procedures (SR)	4	0.998	0.808	0.997
6	Safety Promotion Policies (SP)	4	0.940	0.635	0.938
	Overall fit	29	0.914	-	0.901

If a scale is found to violate the above stipulations, its items are examined and those with the least item-total correlations are taken away so that the reliability is enhanced beyond the minimum requirements. While doing so, it is mandatory to call for the researcher's judgement, as otherwise, reliable scale lacking content validity will result (Ahire et al., 1996). The reliability of the scale developed in the current study is tested by computing Cronbach's alpha (α) value for all the factors. This procedure resulted in removal of 5 items from the instrument. Sufficient care and judgement were used to see that the content validity of each scale is not lost while removing items. The results are presented in Table 3.2. It can be seen from the table that all the factors have Cronbach's alpha value above 0.6, which testifies the reliability of the instrument.

The overall CFI as well as TLI values are above 0.9. All the six factors used in this study have exhibited strong unidimensionality (CFI greater than 0.9), convergent validity (TLI greater than 0.9), and reliability (α greater than 0.6). The scores corresponding to each factor in Table 3.2 reveal this. The instrument thus standardized can be used to measure the levels of safety management practices in industries. We can also compute a 'Safety Management Practice Index (SMP Index)' with respect to each factor for each organization. The SMP Index (for a particular organization, with respect to a particular factor) is the average value (mean value of the respondents' scores) of the scores of the items in that factor. This index can be used as an indicator of the performance of an organization with respect to a particular factor. Decision-makers can use these indices as reference points, upon which improvement efforts can be targeted in the organization. Researchers can also use this work as basis for subsequent studies in other industries, especially in different cultural backgrounds. Such studies can contribute to the enrichment of literature on safety management.

3.3 DISCUSSION ON RELATIONSHIP AMONG THE FACTORS

The discussions based on review of literature on safety management practices reveals that safety management is an integrated approach where there is a lot of interdependence among its dimensions or factors. It has been proved that the 'soft aspects' has a crucial role to play in achieving quality in safety management though they are not quantitative and, hence, difficult to measure. To get a picture of the relationship between the various safety management practices, a bivariate correlation analysis was performed. The results of the analysis are summarized in Table 3.3.

All the correlations are found to be statistically significant at 0.01 significance level. It is to be noted that all the correlations are positive. The high correlations among all the factors indicate a high degree of interdependence among the factors, which support the view that a holistic approach for safety management is indeed appropriate in the case of industrial safety management. There is high correlation between Management Commitment (MC) and all other safety management practices. This finding implies that the impetus for safety management effort should come from the top.

Table 3.3 Bivariate Correlations among the critical factors of safety management

	Mean	S.D.	MC	TR	WI	CO	SR	SP
MC	3.3744	0.8328	1.000					
TR	3.5806	0.8442	0.769**	1.000				
WI	3.2882	0.7720	0.716**	0.681**	1.000			
CO	3.2800	0.8429	0.792**	0.747**	0.748**	1.000		
SR	3.4028	0.8969	0.842**	0.753**	0.695**	0.744**	1.000	
SP	3.1704	0.8412	0.693**	0.641**	0.599**	0.643**	0.686**	1.000

Note: **indicates $P < 0.01$ level (i.e., significance at 1%level) (2-tailed)

3.4 SUMMARY AND CONCLUSIONS

This study attempted to design a comprehensive and yet simple instrument for scientifically examining how concepts and practices involved in safety management can be structured into a systematic framework for understanding the critical factors of safety management in industries and to understand the inter-relationships among those factors. The instrument has been developed and validated based on data collected from major accident hazard industries in Kerala. The results of this present study can be summarized as follows.

- Identification of a list of critical factors of safety management in industries (from the perspective of employees) by addressing the various facets of safety management.

- A holistic framework for safety management has also been proposed. This effort has helped to provide a conceptual clarity in understanding the related issues and the interconnection among critical factors of safety management.

- Development an instrument for measuring the levels of safety management in industries that has been subjected to extensive empirical tests for validity and reliability. The practitioners can use the instrument to measure the level of safety management in their organizations. This use could provide information to the decision-makers for developing their competitive strategies, and to enhance their safety performance.

- The empirical validation of the measuring instrument strives to enrich the subject of theory building (especially in the context of scarcity of empirical research work in the safety management literature).

- This research work attempts to add to the 'not-so-rich' literature available on safety management issues in industries in general and with respect to the emerging developing countries (mostly belonging to developing economies in Asia) in particular.

- Such studies in different types of industries in different cultural and economic background could help the researchers to further understand the structure and relevance of the various aspects of safety management.

The present work adds to the literature by contributing to the establishment of a paradigm for Total Safety Management (TSM) like Total Quality Management (TQM). It also adds to the area of research on TSM in industrial safety management.

CHAPTER 4

RELATIONSHIP BETWEEN SAFETY MANAGEMENT PRACTICES AND ACCIDENTS AND MANAGEMENT SYSTEM CERTIFICATION

Section 4.1 examines the level of safety management practices across organizations. Predictive validity of safety management practices is presented in Section 4.2. Section 4.3 compares organizations based on accident data. Various management system certifications in industries are presented in Section 4.4. Relationship between safety management practices and management system certification is examined in Section 4.5. Section 4.6 contains the summary of this chapter.

The critical safety management practices that have been identified and validated in Chapter 3 and the same set of responses that have been obtained for the study of identification of the critical safety management practices are used in this chapter as well. The critical safety management practices identified are:

1. Management Commitment
2. Safety Training
3. Worker Involvement in Safety
4. Safety Communication and Feedback
5. Safety Rules and Procedures and
6. Safety Promotion Policies.

The aim of safety management is to maintain and promote workers' health and safety at work. Petersen (1988) concluded that unsafe acts, unsafe conditions and accidents are all symptoms of something wrong in the organizational management systems. Furthermore, he stated that it is the top management who is responsible for building up such a system that can effectively control the hazards associated to the organization's operation. This chapter presents a study on the relationship between safety management practices and accident rate and system certification in the selected industrial units.

4.1 THE LEVEL OF SAFETY MANAGEMENT PRACTICES ACROSS ORGANIZATIONS

To explore the level of safety management practices in the organizations under study, the mean of the summated scores of each of the six safety management practices and total safety management score of the eight organizations were computed and the same is presented in Table 4.1.

Table 4.1 Means scores of Safety Management Practices, Accidents and Days lost.

Org	MC	ST	WI	SC	SR	SP	SMP	Acc. Rate	Days Lost
1	3.436	3.810	3.265	3.306	3.513	3.218	20.548	0.0670	0.6295
2	3.279	3.488	3.088	3.111	3.389	3.349	19.703	0.0912	1.2091
3	3.349	3.658	3.270	3.278	3.349	3.199	20.102	0.0988	0.8601
4	3.162	3.092	3.243	3.104	3.138	3.021	18.759	0.0595	0.8333
5	2.895	3.172	2.930	2.840	2.830	2.700	17.366	0.1422	1.7598
6	2.954	3.172	3.088	2.978	3.057	2.499	17.747	0.0643	0.6433
7	3.987	4.236	3.914	3.927	3.991	3.610	23.664	0.0298	0.1429
8	3.886	3.933	3.659	3.751	3.855	3.478	22.561	0.0314	0.1176

4.1.1 Hypothesis to be tested

It is seen that the mean scores of all the six safety management practices and total safety management scores varies from organization to organization. To analyze whether this difference is significant or not, the following hypothesis was formulated.

H_0: There is no significant difference between organizations with respect to the level of six safety management practices.

To test the null hypothesis (H_0), one-way ANOVA F-test was used.

4.1.2 Results and discussion

The result of this ANOVA test is presented in Table 4.2. The ANOVA results indicate that the differences in the levels of all the six safety management practices are significant. Here the alternate hypothesis proposing a difference in the levels of safety management practices has been accepted at less than 0.01 level of significance. Hence, it can be concluded that different organizations have significantly different levels of safety management practices.

Table 4.2 One-way ANOVA. Safety management practices across organizations.

Sl. No.	Safety Management Practices	F value	p value
1	Management Commitment	54.382	0.000**
2	Safety Training	53.859	0.000**
3	Worker Involvement in Safety	41.401	0.000**
4	Safety Communication and Feedback	46.913	0.000**
5	Safety Rules and Procedures	44.151	0.000**
6	Safety Promotion Policies	46.333	0.000**
7	Total Safety Management Score	60.272	0.000**

** indicate $p < 0.01$

This result is in tune with the findings of Donald and Canter (1994) and Mearns et al. (2003). Donald and Canter studied 10 chemical industries with a safety attitude questionnaire and found that the companies differ significantly in their attitude levels. Mearns et al. (2003) conducted survey using safety management questionnaire among 13 offshore oil and gas installations in two separate years and revealed that installations provided significantly different scores in year one across all scales. In the second survey, the installations differed on eight out of ten scales. He also pointed out that a benchmarking approach could be adopted at this point to determine relative weaknesses for any particular installation to provide means of guiding organizational intervention for improvement of safety.

Researches using safety climate factors (Zohar, 1980) and safety management practices (Tinmannsvik and Hovden, 2003) across a variety of different types of industries also found significant differences in safety levels across organizations.

4.2 PREDICTIVE VALIDITY

An essential part of research is to establish the validity of the outcome measurement, which is to verify the degree to which the concept under study is accurately represented by means of measuring the outcome. Injury rate is widely accepted as a valid means of measuring the effect of an injury prevention or safety intervention at a particular worksite (Shannon et al., 1999). Traditional measures of safety performance also rely primarily on some form of accident or injury data (Chhokar and Wallin, 1984). Various studies have revealed that safety climate factors can predict safety-related outcomes, such as accidents or injuries (Zohar, 1980; Brown and Holmes, 1986; Dedobbeleer and Beland, 1991; DeJoy, 1994; Niskanen, 1994; Hofmann and Stetzer, 1996; Diaz and Cabrera, 1997). Some researchers have found that the higher the safety performance, the lower the accident rate (Reber and Wallin, 1983, 1984; Reber et al., 1984; Tyler, 1986).

To explore the relationship between safety management practices and accident data, the accident records maintained by the organizations are required. It was found that the reported accident frequency rates submitted by the companies to the state government were not reliable due to various reasons. Previous studies have also revealed that, the accident frequency rates maintained by the companies are found to be too unreliable to use in research studies, due to high degree of under-reporting (Thompson et al., 1998; Witt et al., 1994; McCurdy et al., 1991; Stout and Bell, 1991; Cooper, 2000). One of the reasons for this under-reporting can be attributed to incentive schemes (Cooper, 2000; Geller, 1994; Promfret, 1994; Krause and Russell, 1994). Due to the above reasons, many researchers have used self-reported accident rates collected from the workers in the survey itself (Mearns et al., 2003; Donald and Canter, 1994; Lee, 1998; Rundmo, 1992, 1994; Williamson et al., 1997) for validation.

Therefore, self-reported accident rates computed from the responses to a question asking the participants to give the number of accidents experienced by them in the year 2002 while working in this company, which resulted in at least 2 lost working days as per Indian Factories Act 1948, and the number of working days lost due to these accidents have been used in this study. The organization-wise mean values of these two measures are also presented in Table 4.1.

Predictive validity of the instrument was examined through correlations among safety management practices and accident data. Given two sites with relatively equal hazard risks, the one with the better safety management score should have fewer accidents. To proceed with this analysis, each organization was considered as a case and the mean scores of the six safety management practices, total safety management score, self-reported accidents and working days lost were computed (Table 4.1).

4.2.1 Hypotheses tested

The following hypotheses were formulated:

$H_{1.1}$: There is significant negative correlation between Management Commitment and the accident data.

$H_{1.2}$: There is significant negative correlation between Safety Training and the accident data.

$H_{1.3}$: There is significant negative correlation between Worker Involvement in Safety and the accident data.

$H_{1.4}$: There is significant negative correlation between Safety Communication and Feedback and the accident data.

$H_{1.5}$: There is significant negative correlation between Safety Rules and Procedures and the accident data.

$H_{1.6}$: There is significant negative correlation between Safety Promotion Policies and the accident data.

$H_{1.7}$: There is significant negative correlation between Total Safety Management Score and the accident data.

To test these hypotheses, Pearson's correlation coefficients were calculated.

4.2.2 Results and discussion

A detailed discussion on the findings of these investigations is presented below.

4.2.2.1 Management Commitment Vs Accident data

Figure 4.1 shows the variation of self-reported accident rate and working days lost with Management Commitment, for the eight industries studied. It can be seen that, as Management Commitment increases, accident rate and working days lost due to these accidents reduce. Pearson's correlation coefficients show that Management Commitment is significantly negatively correlated to accident rate ($r = -0.747$, $p < 0.05$) and days lost ($r = -0.804$, $p < 0.05$). Hence, hypothesis $H_{1.1}$ is supported.

This finding is in tune with that of Mearns et al. (2003) who observed significant negative correlation between Management Commitment and self-reported accident frequency rate in oil installations suggesting that favorable safety management scores have favorable effects on accident proportions.

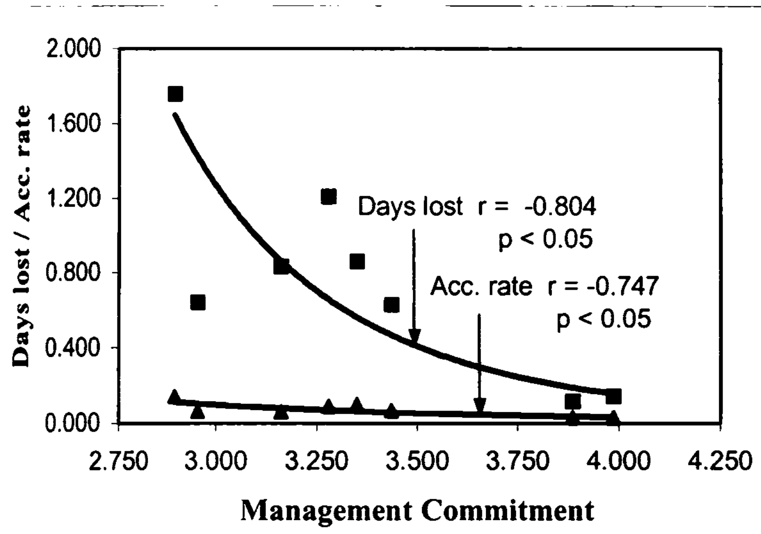

Figure 4.1 Management Commitment Vs Accident data.

4.2.2.2 Safety Training Vs Accident data

Figure 4.2 shows the variation of self-reported accident rate and working days lost with Safety Training for the eight industries studied. It is seen that, as Safety Training increases, accident rate and working days lost due to these accidents reduce. Pearson's correlation coefficients show that Safety Training is negatively correlated to accident rate ($r = -0.579$) and days lost ($r = -0.699$). Even though the correlation coefficients are in the direction consistent with the hypothesis, they failed to attain significance. Hence, hypothesis $H_{1.2}$ is partially supported.

A significant correlation between accident frequency rate and education and training was reported in the study conducted among a variety of manufacturing industries in Norway by Tinmannsvik and Hovden (2003).

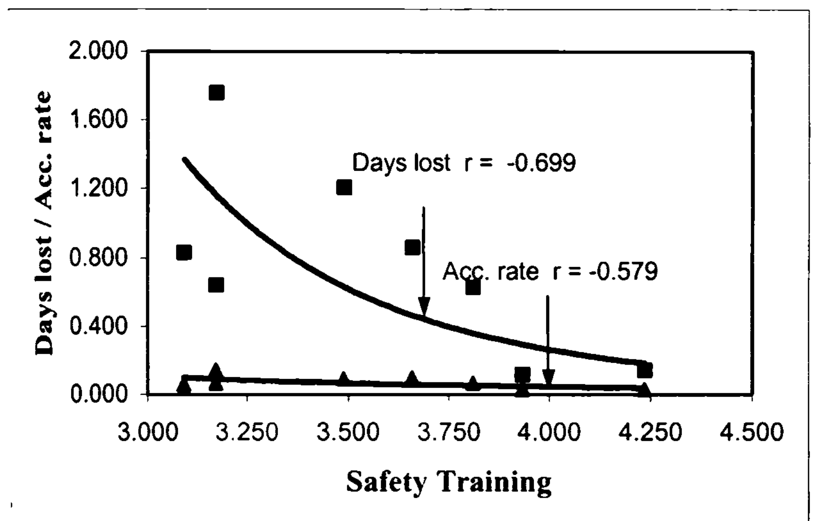

Figure 4.2 Safety Training Vs Accident data

4.2.2.3 Worker Involvement in Safety Vs Accident data

Figure 4.3 shows the variation of self-reported accident rate and working days lost with Safety Training for the eight industries studied. It is seen that, as Worker Involvement in Safety increases, accident rate and working days lost due to these accidents reduce. Pearson's correlation coefficients show that Worker Involvement in Safety is negatively correlated to accident rate ($r = -0.815$, $p < 0.05$) and days lost ($r = -0.859$, $p < 0.01$). This finding supports the hypothesis $H_{1.3}$.

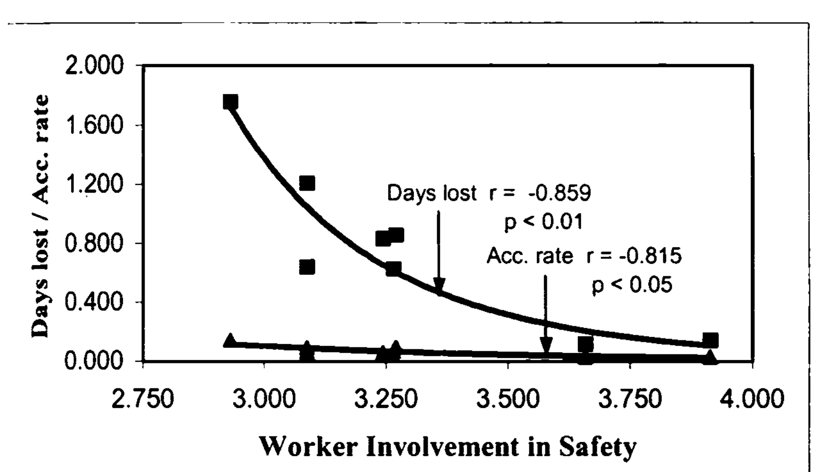

Figure 4.3 Worker Involvement in Safety Vs Accident data.

This finding is in tune with that of Mearns et al. (2003) who observed negative correlation between worker involvement in safety and self-reported accident frequency rate in oil installations in two separate years. In another study, Silva et al. (2004) reported significant negative correlation between personal involvement in safety and accident rate but the correlation between personal involvement and severity rate was not found statistically significant, but was in the expected direction.

4.2.2.4 Safety Communication and Feedback Vs Accident data

Figure 4.4 shows the variation of self-reported accident rate and working days lost with Safety Communication and Feedback for the eight industries studied. It is seen that, as Safety Communication and Feedback increases, accident rate and working days lost due to these accidents reduce. Pearson's correlation coefficients show that Safety Communication and Feedback is negatively correlated to accident rate ($r = -0.782$, $p < 0.05$) and days lost ($r = -0.847$, $p < 0.01$). This finding supports the hypothesis $H_{1.4}$.

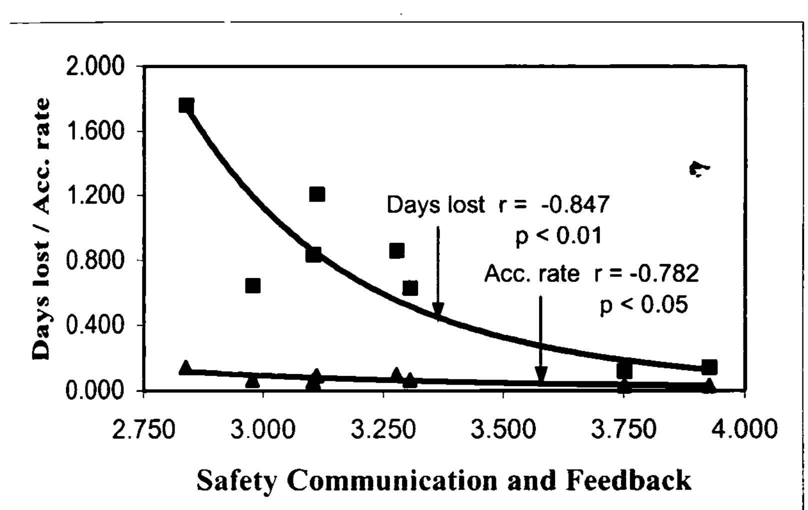

Figure 4.4 Safety Communication and Feedback Vs Accident data

Communication is the key to the relationship between top management and workers. Like in quality management, the system could be damaged if the communication is unusual in safety management. Tinmannsvik and Hovden (2003) have reported a similar significant correlation between safety communication and accident rate in their studies.

4.2.2.5 Safety Rules and Procedures Vs Accident data

Figure 4.5 shows the variation of self-reported accident rate and working days lost with Safety Rules and Procedures for the eight industries studied. The general trend that can be observed from the figure is that, as the score on Safety Rules and Procedures increases, accident rate and working days lost due to these accidents reduce. Pearson's correlation coefficients show that Safety Rules and Procedures is negatively correlated to accident rate ($r = -0.778$, $p < 0.05$) and days lost ($r = -0.828$, $p < 0.05$). This finding supports the hypothesis $H_{1.5}$ which states that Safety Rules and Procedures is having significant negative correlation with the accident data.

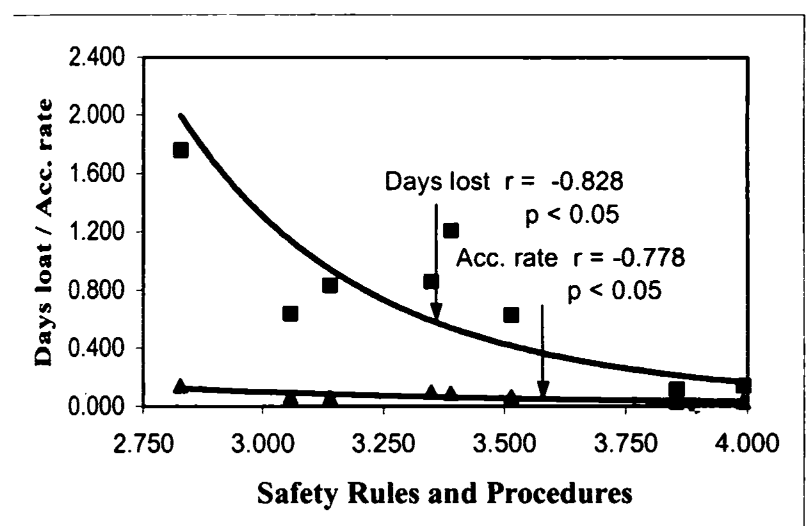

Figure 4.5 Safety Rules and Procedures Vs Accident data

The management of health and safety of workers in Indian industries is governed by the Central Act 63 of 1948 known as "The Factories Act, 1948" formed by Government of India. The state governments have framed rules thereunder to help the state government departments to enforce and monitor the safety rules and procedures that are practiced in industries. Based on the governing rules related to a particular industry, decided by the processes and hazards associated with it, the company manager will produce a "Safety Manual". This safety manual is regarded as the basis for safety management in an industrial organization.

A documented safety manual alone will not help to maintain safety and health of employees. It is the duty of the safety department to see that the employees comply with the safety rules and safe procedures while carrying out a job.

Tinmannsvik and Hovden (2003) have found that "Procedures and activities" is the safety management factor correlating most strongly to the injury frequency rate in their studies on a variety of industries in Norway. Silva et al. (2004) reported that "Strength of safety practices" correlates significantly with accident rates and severity rates in a study conducted in 15 Portuguese organizations covering different sectors.

4.2.2.6 Safety Promotion Policies Vs Accident data

Figure 4.6 shows the variation of self-reported accident rate and working days lost with Safety Promotion Policies for the eight industries studied. A general trend is not visible in the figure to assess the relationship. Pearson's correlation coefficients show that Safety Promotion Policies is negatively correlated to accident rate (r = -0.535) and days lost (r = -0.552). The correlations are not significant but are in the direction consistent with the hypothesis. Hence, hypothesis $H_{1.6}$ is partially supported.

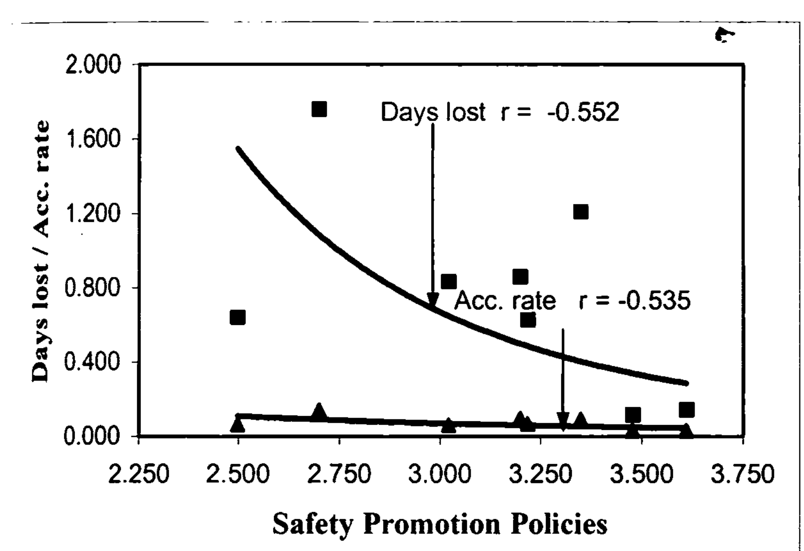

Figure 4.6 Safety Promotion Policies Vs Accident data

Herrero et al. (2002) in the review on traditional safety management and safety integrated with quality, opined that, in traditional safety management, safety is taken care of by motivating the workers using prizes and incentives to help them to work in a safer way. Weinstein (1996) pointed out that traditional safety management programmes do not always improve the results of safety because they are centered exclusively on the technical requirements and on obtaining short-term results. This observation matches with the findings of this research.

4.2.2.7 Total Safety Management Score Vs Accident data

Figure 4.7 shows the variation of self-reported accident rate and working days lost with Total Safety Management Score for the eight industries studied. The general trend that can be observed from the figure is that, as the Total Safety Management Score increases, accident rate and working days lost due to these accidents reduce. Pearson's correlation coefficients show that Total Safety Management Score is negatively correlated to accident rate ($r = -0.728$, $p < 0.05$) and days lost ($r = -0.790$, $p < 0.05$). This finding supports the hypothesis $H_{1.7}$ which states that Total Safety Management Score is having significant negative correlation with the accident data.

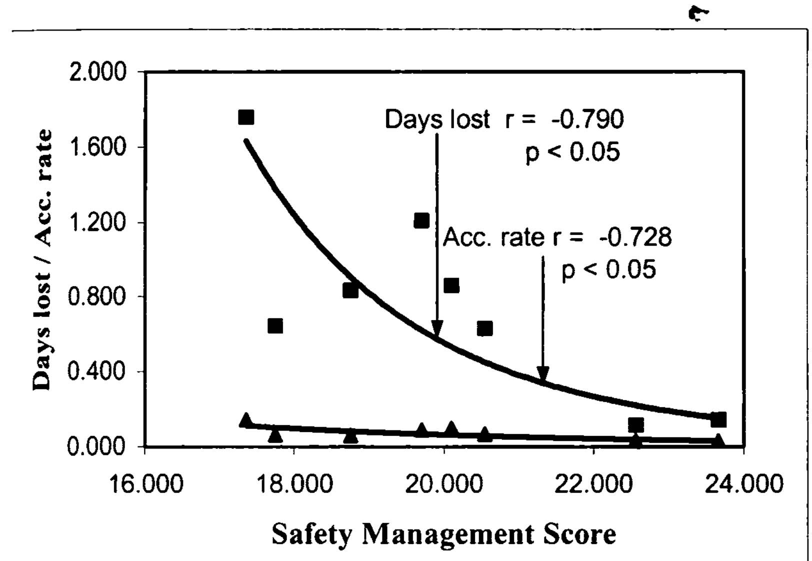

Figure 4.7 Total Safety Management Score Vs Accident data

This finding is in tune with that of Mearns et al. (2003), where the total safety management score was found to be negatively correlated to accident data.

4.3 COMPARISON OF ORGANIZATIONS BASED ON ACCIDENT DATA

4.3.1 Hypothesis to be tested

Once it is established that organizations have different levels of safety management practices in them, and safety management practices are capable of predicting accident rates, it is worth investigating the characteristics of organizations grouped on the basis of accident rates. For this purpose, organizations are classified into 3 groups based on the self-reported accident rate, namely low accident rate (7,8), medium accident rate (1,2,4,6) and high accident rate (3,5) organizations. Organizations with accident rate less than X_1 were classified as low accident rate and those with accident rate greater than X_2 were classified as high accident rate and all those with accident rate in between X_1 and X_2 were classified as medium accident rate organizations,

Where,

X_1 = Mean of accident rate – (0.6 * Standard deviation) = 0.0507

X_2 = Mean of accident rate + (0.6 * Standard deviation) = 0.0953

To test whether there is any significant difference among the groups (based on accident rate), the following hypothesis was formulated.

$H_{0.1}$: There is no significant difference between the groups with respect to each safety management practices.

To test the null hypothesis ($H_{0.1}$), one-way ANOVA F-test, considering all groups together, was used. The result of this ANOVA test is presented in Table 4.3. The results show that there is significant difference between the groups with respect to all the six safety management practices. The total safety management score also differ significantly between the groups. The F statistics for all the above show a significance level beyond 0.001. Therefore, the null hypothesis $H_{0.1}$ is not supported, indicating that there is significant difference between the groups with respect to the safety management practices.

Table 4.3 Difference in the levels of Safety mgmt. Practices with respect to Accidents Results of ANOVA : (all groups taken together)

Safety Mgmt. Practices	Low acc. rate		Medium acc. rate		High acc. rate		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
MC	3.926	0.607	3.236	0.833	3.142	0.788	142.253	0.000**
ST	4.053	0.601	3.436	0.871	3.436	0.823	95.512	0.000**
WI	3.760	0.650	3.158	0.757	3.115	0.730	116.965	0.000**
SC	3.821	0.688	3.132	0.809	3.078	0.832	130.804	0.000**
SR	3.909	0.649	3.313	0.902	3.112	0.899	106.767	0.000**
SP	3.530	0.726	3.103	0.847	2.971	0.830	57.650	0.000**
Total SMP	23.121	3.338	19.427	4.387	18.914	4.209	144.554	0.000**

** indicate $p < 0.01$

Hence, to further explore the relationship between safety management practices and accident rate in industries studied, the following hypotheses ($H_{0.2}$ to $H_{0.4}$) were formulated.

$H_{0.2}$: There is no significant difference between low accident rate and medium accident rate organizations with respect to each safety management practice.

$H_{0.3}$: There is no significant difference between medium accident rate and high accident rate organizations with respect to each safety management practice.

$H_{0.4}$: There is no significant difference between high accident rate and low accident rate organizations with respect to each safety management practice.

These hypotheses were tested using one-way ANOVA, taking two groups of organizations at a time.

4.3.2 Results and discussion

A detailed discussion on the findings of these investigations is presented below.

4.3.2.1 Comparison of low and medium accident rate organizations

Table 4.3 show that the mean scores of all safety management practices in low accident rate organizations are relatively higher than that in medium accident rate organizations.

However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between low accident rate and medium accident rate organizations.

$H_{0.2}$ There is no significant difference between low accident rate and medium accident rate organizations with respect to each safety management practice.

To test the null hypothesis ($H_{0.2}$), ANOVA F-test was used. The result of this ANOVA test is presented in Table 4.4.

Table 4.4 A comparison of Low accident rate Vs Medium accident rate organizations (Results of ANOVA)

Safety Mgmt. Practices	Low acc. rate		Medium acc. rate		F value	p value
	Mean	SD	Mean	SD		
MC	3.926	0.607	3.236	0.833	233.655	0.000**
ST	4.053	0.601	3.436	0.871	174.649	0.000**
WI	3.760	0.650	3.158	0.757	200.687	0.000**
SC	3.821	0.688	3.132	0.809	231.130	0.000**
SR	3.909	0.649	3.313	0.902	149.725	0.000**
SP	3.530	0.726	3.103	0.847	80.738	0.000**
Total SMP	23.121	3.338	19.427	4.387	237.747	0.000**

** indicate $p < 0.01$

From Table 4.4, it is found that the low accident rate firms are significantly different from medium accident firms with respect to all the six safety management practices at 0.01 significance level. All these factors are significantly better for low accident rate firms compared to medium accident rate firms. Hence, the null hypothesis $H_{0.2}$ was rejected and the alternate hypothesis proposing significant difference in the levels of safety management practices was accepted at 0.01 level of significance.

4.3.2.2 Comparison of medium and high accident rate organizations

Table 4.3 shows the mean scores of all safety management practices in medium accident rate organizations and high accident rate organizations. However, empirical investigation is necessary for making any conclusions about their differences. Therefore, the following hypothesis was tested to find the possible differences between medium accident rate and high accident rate organizations.

$H_{0.3}$: There is no significant difference between medium accident rate and high accident rate organizations with respect to each safety management practice.

To test the null hypothesis ($H_{0.3}$), ANOVA F-test was used. The result of this ANOVA test is presented in Table 4.5.

Table 4.5 A comparison of Medium accident rate Vs High accident rate organizations (Results of ANOVA)

Safety Mgmt. Practices	Medium acc. rate		High acc. rate		F value	p value
	Mean	SD	Mean	SD		
MC	3.236	0.833	3.142	0.788	4.002	0.046*
ST	3.436	0.871	3.436	0.823	0.000	0.998(ns)
WI	3.158	0.757	3.115	0.730	1.007	0.316(ns)
SC	3.132	0.809	3.078	0.832	1.347	0.246(ns)
SR	3.313	0.902	3.112	0.899	15.090	0.000**
SP	3.103	0.847	2.971	0.830	7.464	0.006**
Total SMP	19.427	4.387	18.914	4.209	4.237	0.040*

** indicate $p < 0.01$ * indicate $p < 0.05$ ns - non significant

From Table 4.5, it can be seen that the medium accident rate firms are significantly different from high accident rate firms with respect to only three safety management practices, namely, MC, SR and SP. The two groups are not significantly different with respect to the other three safety management practices, namely, ST, WI and SC. Hence the null hypothesis $H_{0.3}$ receives only partial support.

From the above findings, the following conclusions are drawn:

- Greater Management Commitment (MC), better enforcement of Safety Rules and Procedures (SR) and more effective Safety Promotion Policies (SP) contribute significantly towards accident reduction.

- With similar levels of Safety Training (ST), Worker Involvement (WI) and Safety Communication and Feedback (SC), the role of supervisor in enforcing safety rules and procedures become crucial in accident prevention. This is because, supervisor being a link between the management and employees will be demonstrating the management's commitment over the health and safety of employees through his actions and decisions related to safety.

- Safety management needs a holistic philosophy and a set of practices that are to be executed as a whole rather than piece by piece for better safety performance, since it is highly human oriented in nature. This interdependence between the safety management practices was visible in the high bivariate correlations presented in Table 3.3.

4.3.2.3 Comparison of high and low accident rate organizations

Table 4.3 show that the mean scores of all safety management practices in low accident rate organizations are relatively higher than that in high accident rate organizations. Therefore, the following hypothesis was advanced and tested to find whether the differences in the mean scores between the two groups are significant or not.

$H_{0.4}$ There is no significant difference between low accident rate and high accident rate organizations with respect to each safety management practice.

To test the null hypothesis ($H_{0.4}$), ANOVA F-test was used. The result of this ANOVA test is presented in Table 4.6.

Table 4.6 A comparison of High accident rate Vs Low accident rate organizations (Results of ANOVA)

Safety Mgmt. Practices	Low acc. rate		High acc. rate		F value	p value
	Mean	SD	Mean	SD		
MC	3.926	0.607	3.142	0.788	268.302	0.000**
ST	4.053	0.601	3.436	0.823	157.944	0.000**
WI	3.760	0.650	3.115	0.730	188.851	0.000**
SC	3.821	0.688	3.078	0.832	204.909	0.000**
SR	3.909	0.649	3.112	0.899	222.688	0.000**
SP	3.530	0.726	2.971	0.830	111.302	0.000**
Total SMP	23.121	3.338	18.914	4.209	264.936	0.000**

** indicate $p < 0.01$

From Table 4.6, it can be seen that the low accident rate firms are significantly different from high accident firms with respect to all the six safety management practices at 0.01 significance level. All these factors are significantly better for low accident rate firms compared to high accident rate firms. Hence, the null hypothesis $H_{0.4}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety management practices was accepted at 0.01 level of significance.

4.4 MANAGEMENT SYSTEM CERTIFICATION IN INDUSTRY

The long-term success of an organization is dependent on its ability to improve its operations by reorganizing itself, so as to meet the challenging environmental contingencies on a continuous basis (Hitt et al., 1991). Organizations implement several management programmes to remain competitive. TQM and similar system certifications are perhaps the most popular strategies for quality management in manufacturing sector.

After carrying out a study in more than 200 companies for 5 years, Dumas (1987) discovered that programmes of quality and programmes of safety have similar components. One of the conclusions of his study was that "safety is a dimension of quality, after everything, the elimination of defects includes the elimination of practices of unsafe work". Minter (1991) affirms that if one looks at safety, as consequence of making things well, then the programme will undoubtedly bear quality.

Some of the management system accreditations popular in advanced countries are OHSAS 18001 certification, ISRS ranking and ISO 9001 certification. OHSAS 18001 and ISRS are occupational health and safety management based where as ISO 9001 is based on quality management. "Safety" and "Quality" are one and the same, and hence, when any attempt for quality management is made, it also ensures safe work environment for its employees (Carder and Ragan, 2003).

In India, many organizations are ISO 9001 certified, but very few have gone for OHSAS 18001 and ISRS certification. With globalization and opening up of our economy, Indian organizations from various sectors have started to take initiatives to get the above certifications to compete in the international market.

4.4.1 OHSAS 18001 standards

OHSAS 18000 is an international occupational health and safety management system specification. It comprises two parts, 18001 and 18002 and embraces a number of other publications. The following documents and standards related to occupational health and safety, amongst others, were used in the creation process:

- BS8800: 1996 Guide to occupational health and safety management systems
- DNV Standard for Certification of Occupational Health and Safety Management Systems (OHSMS):1997
- Technical Report NPR 5001: 1997 Guide to an occupational health and safety management system
- Draft LRQA SMS 8800 Health & safety management systems assessment criteria
- SGS & ISMOL ISA 2000:1997 Requirements for Safety and Health Management Systems
- BVQI Safety Certification: Occupational Safety and Health Management Standard
- Draft AS/NZ 4801 Occupational health and safety management systems Specification with guidance for use
- Draft BSI PAS 088 Occupational health and safety management systems
- UNE 81900 series of pre-standards on the Prevention of occupational risks
- Draft NSAI SR 320 Recommendation for an Occupational Health and Safety (OH and S) Management System

OHSAS 18001:1999 Standards is an Occupation Health and Safety Assessment Series for health and safety management systems. It is intended to help an organization to control occupational health and safety risks. It was developed in response to widespread demand for a recognized standard against which occupational health and safety system could be certified and assessed.

The OHSAS specification is applicable to any organization that wishes to:

- Establish an Occupational Health and Safety management system to eliminate or minimize risk to employees and other interested parties who may be exposed to Occupational health and safety risks associated with its activities
- Assure itself of its conformance with its stated Occupational Health and Safety policy
- Demonstrate such conformance to others

- Implement, maintain and continually improve an Occupational Health and Safety management system
- Make a self-determination and declaration of conformance with this OHSAS specification.
- Seek certification/registration of its Occupational Health and Safety management system by an external organization

Essentially, OHSAS offer substantial helps to minimize risk to employees, improve an existing occupational health and safety management system, demonstrate diligence, gain assurance etc. Since this accreditation is quite new, there is no research evidence for its validation or comparative study.

4.4.2 ISRS standards

The ISRS is both a management and safety auditing system first introduced by the South African Chamber of Mines. Today, ISRS is a property of independent foundation Det Norske Veritas (DNV), and is widely used throughout the world, which distinguishes 20 safety related elements given below:

- Leadership and administration
- Management Training
- Planned inspections
- Task analysis and procedures
- Accident/incident investigation
- Task observation
- Emergency preparedness
- Organizational rules
- Accident/incident analysis
- Employee training
- Personal protective equipment
- Health control
- Programme evaluation system
- Engineering controls

- Personal communication
- Group meetings
- General promotion
- Hiring and placement
- Purchasing controls
- Off-the-job safety

These 20 elements are divided into 126 sub-elements comprising more than 650 questions. These are either openly formulated or have to be answered with yes or no. From the answers to the questions, the score of each individual element or the total activity level can be calculated out of 10 (ISRS, 1994; Guastello, 1993).

ISRS rating can be considered equivalent to an accreditation or quality certification in industrial safety management as it evaluates the different parts of the company's safety and health activities, and the safety management factors are ranked and assigned a numeric value, based on a qualitative judgment of the relative importance or necessity of the elements (Tinmannsvik and Hovden, 2003).

The validity of ISRS has been tested in several studies. Pringle and Brown (1989) have reported a 12 % drop in accident rates among 2395 North American companies who used ISRS during the period 1978-1979. In another study, among South African gold mines, significant correlation between ISRS rating and accident outcomes was found (Eisner and Leger, 1988).

4.4.3 ISO 9001 standards

ISO 9001 refers to an international standard that establishes procedures and requirements for the management of quality (Elmuti and Kathawala, 1997). It is a very popular standard in Europe. Many quality standards, national as well as international, have incorporated the ISO 9001 standards as a first phase requirement in approving the use of their mark in specific product-certification schemes. The latest version ISO 9001: 2000 is the core module of ISO 9000 series which provides quality systems for design, development, production and services. This consists of quality management principles like management commitment, communication, work environment, involvement of people etc, which are key safety management practices. ISO 9001 standards have helped many organizations implement quality integrated safety management since they describe the essential elements (Herrero et al., 2002).

4.5 RELATIONSHIP BETWEEN SAFETY MANAGEMENT PRACTICES AND MANAGEMENT SYSTEM CERTIFICATION

From the review of literature, it appears that studies that explore the relationship between safety management practices and system certification have not been conducted in India so far. This finding indicates a gap in literature on safety management. Considering the increase in industrial accidents and loss to life, material and environment, more and more organizations are voluntarily embracing management system certifications. Hence, there is a need for exploring the relationship between safety management practices and system certification. The results of the present study would be of great practical relevance to safety managers and decision makers in industrial safety all over the world.

The certification status of the organizations at the time of this study is presented below:

Not certified	-Organizations 2,4 and 5.
ISO 9001 certified	-Organizations 1,3 and 6.
ISRS certified	-Organization 8 (This organization was waiting for the result of the inspection by certifying authorities and was later awarded 7 points out of 10 by DNV).
OHSAS 18001 certified	-Organization 7.

4.5.1 Hypotheses to be tested

To explore the relationship between safety management practices and management system certification, the firms are initially classified into two groups (based on system certification), namely, system certified and non-certified firms. The system certified firms are further classified into ISO certified, OHSAS certified and ISRS certified firms (see Fig. 4.8). To test whether there is any difference between the groups (based on system certification), the following hypothesis was formulated.

$H_{0.5}$: There is no significant difference between the groups with respect to each safety management practice.

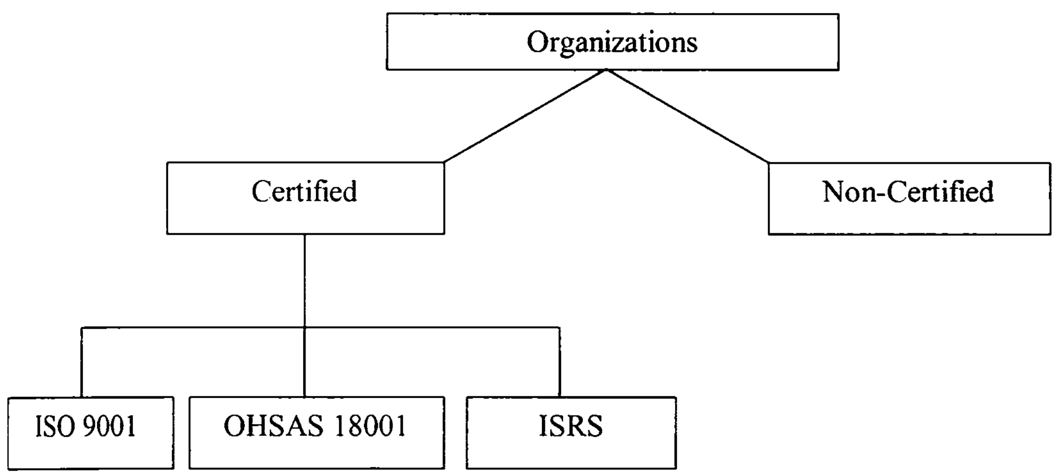

Figure 4.8 Classification of Organizations under study

4.5.2 Methodology

To test the null hypothesis ($H_{0.5}$), one-way ANOVA F-test, considering all groups together, was used. The result of this test is presented in Table 4.7.

Table 4.7 Difference in the levels of Safety Management Practices with respect to system certification. Results of ANOVA: (all groups taken together)

Safety Mgmt.	OHSAS-certified		ISRS-certified		ISO-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
MC	3.987	0.593	3.886	0.613	3.274	0.832	3.147	0.805	97.26	0.000**
ST	4.236	0.514	3.933	0.624	3.581	0.839	3.312	0.850	83.78	0.000**
WI	3.914	0.642	3.659	0.637	3.219	0.721	3.080	0.766	87.11	0.000**
SC	3.927	0.689	3.751	0.680	3.207	0.822	3.035	0.804	94.87	0.000**
SR	3.991	0.635	3.856	0.653	3.328	0.893	3.179	0.911	69.74	0.000**
SP	3.610	0.729	3.477	0.721	3.018	0.839	3.097	0.846	37.70	0.000**
SMP	23.760	3.222	22.700	3.353	19.694	4.339	18.890	4.331	102.2	0.000**

** indicate $p < 0.01$

The results show that there is significant difference between the groups with respect to all the six safety management practices at 0.01 significance level. Therefore, the null hypothesis $H_{0.5}$ is not supported, indicating that there is significant difference between the groups with respect to the safety management practices. Figure 4.9 shows the mean scores of the six safety management practices for the four groups for a comparative study. Hence, to further explore the relationships between safety management practices and system certifications, the following hypotheses ($H_{0.6}$ to $H_{0.12}$) were formulated.

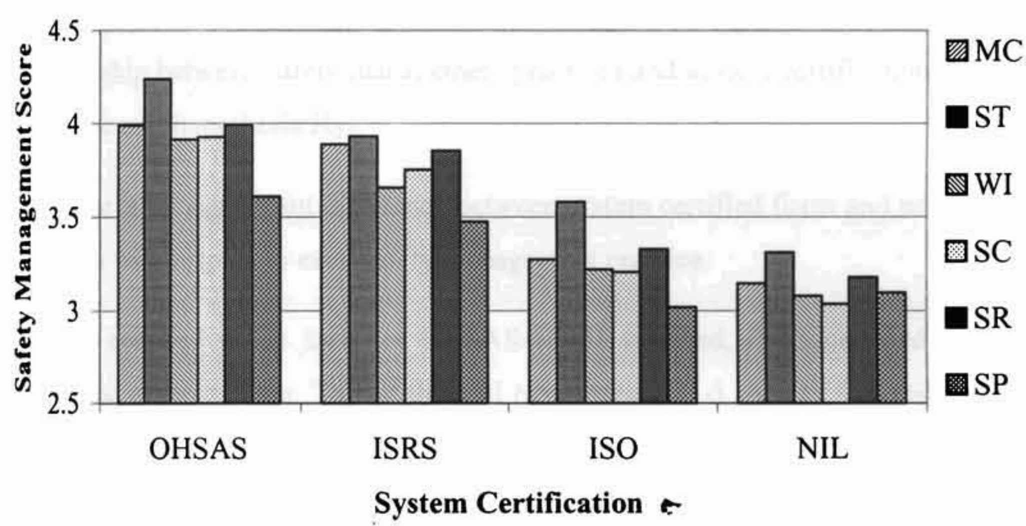

Figure 4.9 System Certification Vs Safety Management Practices

$H_{0.6}$: There is no significant difference between system certified firms and non-certified firms with respect to each safety management practice.

$H_{0.7}$: There is no significant difference between OHSAS-18001 certified firms and non-certified firms with respect to each safety management practice.

$H_{0.8}$: There is no significant difference between ISRS certified firms and non-certified firms with respect to each safety management practice.

$H_{0.9}$: There is no significant difference between ISO-9001 certified firms and non-certified firms with respect to each safety management practice.

$H_{0.10}$: There is no significant difference between OHSAS-18001 certified firms and ISRS certified firms with respect to each safety management practice.

$H_{0.11}$: There is no significant difference between OHSAS-18001 certified firms and ISO-9001 certified firms with respect to each safety management practice.

$H_{0.12}$: There is no significant difference between ISRS certified firms and ISO-9001 certified firms with respect to each safety management practice.

These hypotheses were tested by ANOVA, taking two groups of organizations at a time.

4.5.3 Results and discussion

A detailed discussion on the findings of the investigation is presented below.

4.5.3.1 Comparison between Certified and Non-Certified Organizations

The relationship between safety management practices and system certification is studied by testing the null hypothesis $H_{0.6}$.

$H_{0.6}$: There is no significant difference between system certified firms and non-certified firms with respect to each safety management practice.

The system certified group includes OHSAS-18001 certified, ISRS certified and ISO-9001 certified organizations. To test the null hypothesis ($H_{0.6}$), ANOVA F-test was used to find whether there is any significant difference between system-certified and non-certified groups, with respect to critical safety management practices. The results of this ANOVA test are presented in Table 4.8.

Table 4.8 A comparison of system certified and non-certified firms (Results of ANOVA)

Safety mgmt. practices	Certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.534	0.815	3.147	0.805	99.316	0.000**
ST	3.769	0.788	3.312	0.850	138.206	0.000**
WI	3.435	0.742	3.080	0.766	97.616	0.000**
SC	3.452	0.828	3.035	0.804	113.639	0.000**
SR	3.560	0.853	3.179	0.911	82.387	0.000**
SP	3.222	0.834	3.097	0.846	9.708	0.002**
SMP	21.060	4.309	18.890	4.331	111.16	0.000**

** indicate $p < 0.01$

It is found that there are significant differences beyond 0.01 level among the two groups with respect to all the six critical safety management practices. Therefore, the null hypothesis $H_{0.6}$ was rejected. Thus, it can be concluded that in certified companies there is a significant and prominent presence of safety management practices such as MC, ST, WI, SC, SR and SP when compared to non-certified companies. A comparison of the mean values of each practice indicates that system-certified organizations have better safety management practices.

It can be concluded that industrial organizations need to go for system certification (preferably in safety) not only to equip themselves to compete internationally, but also to improve safety standards which will reduce accidents, production loss and workers' compensatory expenses. The findings of this study thus highlight the necessity for such a study.

4.5.3.2 Comparison between OHSAS Certified and Non-Certified Organizations

From the above discussions on system certified firms Vs non-certified firms, it appears that firms with OHSAS 18001 standards are better than non-certified firms in all safety management practices. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between OHSAS 18001 certified and non-certified organizations.

$H_{0.7}$: There is no significant difference between OHSAS-18001 certified firms and non-certified firms with respect to each safety management practice.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 4.9.

From Table 4.9, it is found that the OHSAS 18001 certified firms are significantly different from non-certified firms with respect to all the six safety management practices at 0.01 significance level. All these factors are significantly better for OHSAS certified firms compared to non-certified firms. Hence, the null hypothesis $H_{0.7}$ was rejected and the alternate hypothesis proposing a significant difference in the levels of safety management practices has been accepted at 0.01 level of significance.

From the results it can be concluded that OHSAS 18001 certification helps the organization to have improved safety management practices to take care of safety of its employees.

Table 4.9 Comparison of OHSAS 18001 certified Vs Non-certified organizations (Results of ANOVA)

Safety mgmt. practices	OHSAS-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.987	0.593	3.147	0.805	162.675	0.000**
ST	4.236	0.514	3.312	0.850	183.361	0.000**
WI	3.914	0.642	3.080	0.766	172.085	0.000**
SC	3.927	0.689	3.035	0.804	177.482	0.000**
SR	3.991	0.635	3.179	0.911	120.167	0.000**
SP	3.610	0.729	3.097	0.846	52.92	0.000**
SMP	23.760	3.222	18.890	4.331	191.132	0.000**

** indicate $p < 0.01$

4.5.3.3 Comparison between ISRS Certified and Non-Certified Organizations

From the discussions on system-certified firms Vs non-certified firms, it appears that firms with ISRS standards are better than non-certified firms in all safety management practices. To find out whether the observed difference in the mean values of safety management practices in ISRS certified and non-certified firms are significant or not, the following hypothesis was tested.

$H_{0.8}$: There is no significant difference between ISRS certified firms and non-certified firms with respect to each safety management practice.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 4.10.

From Table 4.10, it can be seen that the ISRS certified firms are significantly different from non-certified firms with respect to all the six safety management practices at 0.01 significance level. All these factors are significantly better for ISRS certified firms compared to non-certified firms. Hence, the null hypothesis $H_{0.8}$ was rejected and the alternate hypothesis proposing a significant difference in the levels of safety management practices has been accepted at 0.01 level of significance.

Table 4.10 Comparison of ISRS certified Vs Non-certified organizations (Results of ANOVA)

Safety mgmt. practices	ISRS-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.886	0.613	3.147	0.805	179.061	0.000**
ST	3.933	0.624	3.312	0.850	114.796	0.000**
WI	3.659	0.637	3.080	0.766	118.005	0.000**
SC	3.751	0.680	3.035	0.804	162.469	0.000**
SR	3.856	0.653	3.179	0.911	119.202	0.000**
SP	3.477	0.721	3.097	0.846	41.288	0.000**
SMP	22.700	3.353	18.890	4.331	165.626	0.000**

** indicate $p < 0.01$

4.5.3.4 Comparison between ISO 9001Certified and Non-Certified Organizations

From the discussions on system-certified firms Vs non-certified firms, it appears that firms with ISO certification are better than non-certified firms in most of the safety management practices. Such conclusions cannot be arrived at without empirical testing. Therefore, the following hypothesis was tested to find the possible differences between ISO certified and non-certified organizations.

H_{09}: There is no significant difference between ISO 9001 certified firms and non-certified firms with respect to each safety management practice.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 4.11.

From Table 4.11, it can be seen that the ISO certified firms are significantly different from non-certified firms with respect to five out of the six safety management practices at 0.01 significance level. All these factors are significantly better for ISO certified firms compared to non-certified firms. But the level of Safety Promotion Policies (SP) is not significantly different for the two groups. It is seen that in non-certified firms, the level of SP is comparatively high and almost equals that in ISO certified firms. This finding is in tune with the observation of Herrero et al. (2002) who opined that, in traditional safety management, safety is taken care of by motivating the workers using prizes and incentives to help them to work in a safer way. Rewards are given only to those workers or departments that meet the preset safety objectives (Smith, 1996). The traditional safety management programmes (used by non-certified firms) do not always improve the results of safety because they are centered exclusively on the technical requirements and on obtaining short-term results (Weinstein, 1996)

Table 4.11 Comparison of ISO certified Vs Non-certified organizations (Results of ANOVA)

Safety mgmt. practices	ISO-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.274	0.832	3.147	0.805	8.216	0.004**
ST	3.581	0.839	3.312	0.850	34.901	0.000**
WI	3.219	0.721	3.080	0.766	12.032	0.001**
SC	3.207	0.822	3.035	0.804	15.426	0.000**
SR	3.328	0.893	3.179	0.911	9.387	0.002**
SP	3.018	0.839	3.097	0.846	3.046	0.081(ns)
SMP	19.694	4.339	18.890	4.331	11.897	0.001**

** indicate $p < 0.01$ (ns) indicate non significant

Hence the null hypothesis $H_{0.9}$ was partially rejected and the alternate hypothesis proposing a significant difference in the levels of safety management practices has been partially accepted at 0.01 level of significance.

4.5.3.5 Comparison between OHSAS Certified and ISRS Certified Organizations

From Table 4.7, it appears that firms with OHSAS standards are better than ISRS certified firms in all safety management practices. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between OHSAS certified and ISRS certified organizations.

$H_{0\,10}$: There is no significant difference between OHSAS certified firms and ISRS certified firms with respect to each safety management practice.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 4.12.

From Table 4.12, it can be seen that the OHSAS certified firms are significantly different from ISRS certified firms with respect to three safety management practices (namely, ST, WI and SC) out of the six safety management practices at 0.01 significance level, while the factor SR is significantly different at 0.05 significance level. All these factors are significantly better for OHSAS certified firms compared to ISRS certified firms. There appears to be no significant difference with respect to two safety management practices, namely, Management Commitment (MC) and Safety Promotion Policies (SP). Therefore, the null hypothesis $H_{0.10}$ was partially accepted.

Table 4.12 Comparison of OHSAS 18001 certified Vs ISRS certified organizations (Results of ANOVA)

Safety mgmt. practices	OHSAS-certified		ISRS-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.987	0.593	3.886	0.613	2.810	0.094(ns)
ST	4.236	0.514	3.933	0.624	27.384	0.000**
WI	3.914	0.642	3.659	0.637	16.131	0.000**
SC	3.927	0.689	3.751	0.680	6.721	0.010**
SR	3.991	0.635	3.856	0.653	4.495	0.035*
SP	3.610	0.729	3.477	0.721	3.399	0.066(ns)
SMP	23.760	3.222	22.700	3.353	10.433	0.001**

** indicate $p < 0.01$ * indicate $p < 0.05$ (ns) indicate non-significant

It can be concluded from the results that OHSAS 18001 standards and requirements are more effective than that of ISRS for managing safety in industries.

4.5.3.6 Comparison between ISRS Certified and ISO 9001 Certified Organizations

From Table 4.7, it appears that firms with ISRS standards are better than ISO certified firms in all safety management practices. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between ISRS certified and non-certified organizations.

$H_{0.11}$: There is no significant difference between ISRS certified firms and ISO certified firms with respect to each safety management practice.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 4.13.

From Table 4.13, it can be seen that the ISRS certified firms are significantly different from ISO certified firms with respect to all the six safety management practices at 0.01 significance level. All these factors are significantly better for ISRS certified firms compared to ISO certified firms. Hence, the null hypothesis $H_{0.11}$ was rejected and the alternate hypothesis proposing a significant difference in the levels of safety management practices has been accepted at 0.01 level of significance.

Table 4.13 Comparison of ISRS certified Vs ISO certified organizations (Results of ANOVA)

Safety mgmt. practices	ISRS-certified		ISO-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.886	0.613	3.274	0.832	113.205	0.000**
ST	3.933	0.624	3.581	0.839	36.586	0.000**
WI	3.659	0.637	3.219	0.721	72.252	0.000**
SC	3.751	0.680	3.207	0.822	87.588	0.000**
SR	3.856	0.653	3.328	0.893	73.060	0.000**
SP	3.477	0.721	3.018	0.839	59.131	0.000**
SMP	22.700	3.353	19.694	4.339	98.826	0.000**

** indicate $p < 0.01$

4.5.3.7 Comparison between OHSAS Certified and ISO 9001Certified Organizations

From Table 4.7, it appears that firms with OHSAS standards are better than ISO certified firms in all safety management practices. To find out whether the observed difference in the mean values of safety management practices in OHSAS certified and ISO certified firms are significant or not, the following hypothesis was tested.

$H_{0.12}$: There is no significant difference between OHSAS certified firms and ISO certified firms with respect to each safety management practice.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 4.14.

From Table 4.14, it can be seen that the OHSAS certified firms are significantly different from ISO certified firms with respect to all the six safety management practices at 0.01 significance level. All these factors are significantly better for OHSAS 18001 certified firms compared to ISO certified firms. Hence, the null hypothesis $H_{0.12}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety management practices has been accepted at 0.01 level of significance.

Table 4.14 Comparison of OHSAS 18001 certified Vs ISO certified organizations (Results of ANOVA)

Safety mgmt. practices	OHSAS-certified		ISO-certified		F value	p value
	Mean	SD	Mean	SD		
MC	3.987	0.593	3.274	0.832	108.561	0.000**
ST	4.236	0.514	3.581	0.839	92.938	0.000**
WI	3.914	0.642	3.219	0.721	128.874	0.000**
SC	3.927	0.689	3.207	0.822	108.683	0.000**
SR	3.991	0.635	3.328	0.893	81.688	0.000**
SP	3.610	0.729	3.018	0.839	69.883	0.000**
SMP	23.760	3.222	19.694	4.339	128.799	0.000**

** indicate $p < 0.01$

4.6 SUMMARY

In this chapter, an attempt was made, with the help of empirical research, to understand the relationship between safety management practices and self-reported accident rate. The effect of system accreditation related to industrial safety on the safety management practices have also been investigated. The responses collected from the employees through a survey using questionnaire was used for the various analyses.

Initially, a hypothesis (H_0) was tested using ANOVA to find whether there are any significant differences among the industries under study with respect to the safety management practices identified in this research. As the results showed significant difference between organizations, a set of hypotheses (H_1 to H_7) has been developed to test the relationship between each safety management practice and accident rate. It was found that all the six safety management practices and the total score were negatively correlated to accident rate and working days lost due to these accidents. Only Safety Training and Safety Promotion Policies failed to attain significance. Worker Involvement in Safety emerged as a key predictor of both accident rate and lost working days by showing the strongest correlations.

For further investigation, the organizations were classified into three groups, namely, low accident rate, medium accident rate and high accident rate and hypothesis $H_{0.1}$ was tested using ANOVA to find whether there is any significant difference between the groups based on the safety management practices. The results showed significant difference and hence, a set of hypotheses ($H_{0.2}$ to $H_{0.4}$) has been formulated to test the difference between each group pair. It was found that low accident rate organizations have better safety management practices and they differed significantly with the other two groups on all safety management practices. But, medium accident rate organizations showed significant difference with high accident rate organizations only on three management practices, namely, MC, SR and SP. This leads to the conclusion that, medium accident rate organizations have better MC, SR and SP compared with high accident rate organizations and those management practices have a major role in preventing accidents by enforcing rules and offering incentives for working safely. Since these three management practices are more associated to supervisors/first level officers, it is evident that their attitude towards safety of employees and initiatives for demonstration of commitment of management for promoting health and safety of its employees play a crucial role in accident prevention.

To study the effect of system certification on safety management, organizations were classified into certified and non-certified firms. Hypothesis $H_{0.5}$ was tested using ANOVA to find any significant difference between them on the basis of the level of safety management practices. As the analysis showed significant difference, the certified firms were classified into OHSAS certified, ISRS certified and ISO certified firms and a set of hypotheses ($H_{0.6}$ to $H_{0.12}$) were formulated. ANOVA tests conducted for each pair showed that ISO certified firms and non-certified firms do not differ significantly with respect to SP. Another finding was that, OHSAS certified and ISRS certified firms do not differ significantly with respect to MC and SP.

It was also found that OHSAS certified organizations have better safety management practices compared to ISRS certified and ISO certified organizations.

CHAPTER 5

IDENTIFICATION OF DETERMINANTS AND COMPONENTS OF SAFETY PERFORMANCE AND THEIR RELATIONSHIP WITH SAFETY MANAGEMENT PRACTICES, PERSONAL ATTRIBUTES, MANAGEMENT SYSTEM CERTIFICATION AND ACCIDENTS

The objectives of the study presented in this chapter are given in Section 5.1. Section 5.2 identifies the determinants of safety performance, followed by a detailed discussion. Section 5.3 describes the development of instrument, validation, analyses, results and discussions along with relationship between safety management practices and determinants of safety performance, impact of personal attributes on determinants of safety performance, impact of system certification on determinants of safety performance and impact of accidents on determinants of safety performance. Section 5.4 identifies the components of safety performance, followed by a detailed discussion. Section 5.5 describes the development of instrument, validation, analyses, results and discussions along with relationship between determinants and components of safety performance, impact of personal attributes on components of safety performance, impact of system certification on components of safety performance and impact of accidents on components of safety performance. A model of safety performance using SEM is presented in Section 5.6. Section 5.7 provides a summary of the research findings.

5.1 OBJECTIVES OF THE STUDY

This study presented in this chapter was conducted to investigate the following:

- What are the determinants of safety performance?
- Is there any relationship between safety management practices and determinants of safety performance?

- Do personal attributes such as qualification, age, tenure, job category and accident history have any impact on determinants of safety performance?
- Do management system certifications have any impact on determinants of safety performance?
- Do accident rates in organizations have any relationship with determinants of safety performance?
- What are the components of safety performance?
- Is there any relationship between determinants of safety performance and components of safety performance?
- Do personal attributes such as qualification, age, tenure, job category and accident history have any impact on components of safety performance?
- Do management system certifications have any impact on components of safety performance ?
- Do accident rates in organizations have any relationship with components of safety performance?
- To model safety performance with the help of antecedents, determinants and components of safety performance and to test it statistically.

5.2 IDENTIFICATION OF DETERMINANTS OF SAFETY PERFORMANCE

Determinants of safety performance represent the factors directly responsible for individual differences in safety performance components. Based on an extensive survey of literature on safety performance and discussions with experienced safety professionals in industries and management experts from academics, two determinants of safety performance have been identified. They are Safety Knowledge (KNO) and Safety Motivation (MOT).

5.2.1 Safety Knowledge

It is reported that, in any activity, knowledge can be considered as a determinant of performance. In order to apply previously obtained knowledge to practical problems efficiently, one likely requires the well-organized storage of concepts, since the retrieved knowledge is a necessary precursor to the use of stored knowledge. In addition to the previously obtained safety knowledge, safety training, worker involvement in safety related matters, vertical and horizontal communication about safety issues, written down procedures specifying the sequence of operations etc. will supplement safety knowledge (Smith-Crowe et al., 2003). Several studies (e.g., Griffin and Neal, 2000; Burke et al., 2002) have found empirical support for hypothesized positive relationships among amount of perceived safety knowledge and self ratings of safety performance. For instance, Burke et al. (2002) reported that, safety knowledge, with respect to specific dimensions of safety performance, was positively related to safety performance on each performance dimension respectively. They also observed that the level of safety climate, which is related to the level of existing safety management practices in an organization, has bearing on the safety knowledge – safety performance relationships.

5.2.2 Safety Motivation

In occupational safety and health, motivation increases the awareness, interest, and willingness of employees to act in ways that increase their personal safety and health, and that of co-workers, and that support an organization's stated goals and objectives (Hagan et al., 2001). Individual differences like motivation for safety is to be considered when analyzing safety performance at individual level. Just as one can discuss the advantages of detailed safe procedures for carrying out a work, one cannot always control the attitude and motivation of the employees using these procedures (Hofmann et al., 1995). The employees should be motivated to think about safety and to act in safe ways (Donald and Canter, 1994). Available evidence suggests that motivation is an important determinant of individual differences in performance across a wide range of contexts (Neal et al., 2000).

The motivation to perform a job in a safe manner is a function of both the individual's own concern with safety as well as management's expressed concern for safety (Zohar, 1980). Various safety management practices such as demonstration of management commitment, safety training, communication, involvement of workers in safety related activities, enforcement of safety rules and procedures, incentives and rewards etc. are found to assist to inculcate a positive attitude towards safety among the employees.

5.3 VALIDATION OF THE INSTRUMENT: DATA COLLECTION, ANALYSIS, RESULTS AND DISCUSSION

5.3.1 Methodology and Validation of the Instrument

Data was collected through the same instrument referred in Chapter 3, which was used to measure the safety management practices. Twelve questions were included to measure the two determinants of safety performance, namely, Safety Knowledge and Safety Motivation (see Appendix). The content validity and face validity have been assured in the initial stagers of the questionnaire development. Eight items were phrased positively and the remaining four negatively. The unidimensionality and validity of this instrument have been tested by running confirmatory factor analysis using AMOS-4 software and reliability was assessed using SPSS-10. The results are presented in Table 5.1. Two items, one each from Safety Knowledge and Safety Motivation were removed from the scale due to low item-total correlations.

Table 5.1.Results of Confirmatory Factor Analysis: Unidimensionality, Convergent Validity and Reliability coefficients for determinants of safety performance.

Sl No	Determinants of safety performance	No.of items	Comparative Fit Index (CFI)	Cronbach's Alpha (α)	Tucker-Lewis Index (TLI)
1	Safety Knowledge (KNO)	5	0.987	0.765	0.974
2	Safety Motivation (MOT)	5	0.973	0.724	0.945
	Overall	10	0.926	-	0.903

It can be seen that both the measures exhibit strong unidimensionality (CFI greater than 0.9), convergent validity (TLI greater than 0.9) and reliability (Cronbach's alpha (α) greater than 0.6).

5.3.2 Bivariate correlation between the independent and dependent variables

The bivariate correlation between the independent variables and the dependent variable is tested using the responses. SPSS-10 software was used for this purpose. The results are presented in Table 5.2. Each determinant of safety performance is positively correlated with all safety management practices at significance level beyond 0.01, thereby indicating that these measures are strong predictors of the dependent variable.

Table 5.2 Bivariate Correlations among the safety management practices and the two determinants of safety performance

	Mean	S.D.	MC	TR	WI	CO	SR	SP	KNO	MOT
MC	3.374	.833	1.00							
TR	3.580	.844	.769**	1.00						
WI	3.288	.772	.716**	.681**	1.00					
CO	3.280	.843	.792**	.747**	.748**	1.00				
SR	3.403	.897	.842**	.753**	.695**	.744**	1.00			
SP	3.170	.841	.693**	.641**	.599**	.643**	.686**	1.00		
KNO	3.914	.588	.427**	.432**	.385**	.445**	.438**	.350**	1.00	
MOT	4.455	.483	.240**	.280**	.232**	.217**	.214**	.191**	.415**	1.00

** indicates $p < 0.01$

5.3.3 Relationship between safety management practices and determinants of safety performance

Relationship between two variables is termed as 'collinearity', and the relation between variables in the case of more than two variables is termed as 'multicollinearity'. Two variables are said to exhibit complete collinearity if their correlation coefficient is one, and complete lack of collinearity if their correlation coefficient is zero. Multicollinearity occurs when any single independent variable is highly correlated with a set of other independent variables.

The use of several variables as predictors makes the assessment of multiple correlations between independent variables necessary to identify multicollinearity. But this is not possible by examining only the correlation matrix. Multicollinearity can be assessed by computing the "Variance Inflation Factor" or VIF for each construct. Multicollinearity is said to exist if the VIF exceeds 10 (the usual threshold value), which means that collinearity does not explain more than 10 % of any independent variable's variance (Hair et al., 1998). In the present study, the maximum VIF (among the independent variables) is found to be much below 10 (see Table 5.3 and Table 5.4). This is an indication that the level of multicollinearity is not high.

5.3.3.1 Multiple Regression Analysis

To find out the relationship between the determinants of safety performance and safety management practices, the following questions have been investigated:

- Is there any significant positive relationship between the safety management practices and Safety Knowledge (KNO)?
- Is there any significant positive relationship between the safety management practices and Safety Motivation (MOT)?

Multiple Regression Analysis was done to investigate the relationship between the safety management practices and the determinants of safety performance (KNO and MOT), using SPSS-10 software. The safety management practices were treated as predictor variables and each of the determinants of safety performance were treated as the dependent variable. The results are presented in Table 5.3 and Table 5.4 respectively.

The results of the 'F' statistics for the model with respect to Safety Knowledge indicate that the model is significant ($p < 0.01$), and hence it can be used for explanation purposes. The R^2 value indicates that the independent variables (safety management practices) are collectively able to explain a good amount of variation in the dependent variable (Safety Knowledge). From Table 5.3, it could also be inferred that the 't' statistics for three (out of six) independent variables, namely ST, SC and SR, have turned out to be significant ($p < 0.01$) in explaining the variation in the determinant of safety performance.

The results of the 'F' statistics for the model with respect to Safety Motivation indicate that the model is significant ($p < 0.01$), and hence it can be used for explanation purposes. The R^2 value indicates that the independent variables (safety management practices) are collectively able to explain only a small percentage of variation in the dependent variable (Safety Motivation). From Table 5.4, it could also be inferred that the 't' statistics for only two (out of six) independent variables, namely ST and WI, have turned out to be significant ($p< 0.05$) in explaining the variation in the determinant of safety performance, namely, Safety Motivation.

Table 5.3 Relation between Safety Management Practices and Safety Knowledge
Results of Multiple Regression Analysis

Multiple R = 0.481 R^2 = 0.232	Adjusted R^2 = 0.229 Std. Error = 0.516	F = 90.398 Sig. 0.000**

Factor	Beta	VIF	t	significance
MC	0.014	4.779	0.300	0.764
ST	0.140	3.068	3.881	0.000**
WI	0.023	2.640	0.672	0.502
SC	0.189	3.577	4.835	0.000**
SR	0.161	4.058	3.807	0.000**
SP	0.005	2.170	0.178	0.859

** indicate $p < 0.01$

Table 5.4 Relation between Safety Management Practices and Safety Motivation
Results of Multiple Regression Analysis

Multiple R = 0.289 R^2 = 0.084	Adjusted R^2 = 0.081 Std. Error = 0.463	F = 27.403 Sig. 0.000**

Factor	Beta	VIF	t	significance
MC	0.082	4.779	1.653	0.098
ST	0.237	3.068	6.008	0.000**
WI	0.089	2.640	2.424	0.015*
SC	-0.045	3.577	-1.065	0.287
SR	-0.062	4.058	-1.372	0.170
SP	0.001	2.170	0.025	0.980

** indicate $p < 0.01$ * indicate $p < 0.05$

The low values of R^2 in predicting Safety Knowledge and Safety Motivation can be attributed to the high literacy level in Kerala. The people in Kerala are generally literate and already possess good knowledge in safety related matters and are highly motivated with regards to safety. The results of the present study reveal that Safety Training is capable of explaining both Safety knowledge and Safety Motivation. The positive relationship between safety training and safety knowledge have been repeatedly highlighted by many researchers (e.g., Anderson, 1987; Baldwin and Ford, 1988; Stout et al., 1997). The predictive capacity of Safety Training on Safety Motivation is in tune with the theories of motivational techniques found in Hagan et al. (2001). An interesting observation from this study is that the data failed to testify the positive relationship of Safety Communication, Safety Rules and Procedures and Safety Promotion Policies with Safety Motivation given in Hagan et al. (2001).

5.3.4 Impact of personal attributes on determinants of safety performance

The weak linear relationship between determinants of safety performance (KNO and MOT) and the safety management practices indicate that some other variables may be influencing the determinants of safety performance. Hence it is decided to investigate the impact of personal variables such as qualification, age, years of experience in the organization, job category and accident history of the employee on determinants of safety performance. The data collected from the respondents through the demographic items of the questionnaire is used for this purpose.

5.3.4.1 Impact of qualification on determinants of safety performance

To study the relationship between qualification of employees and determinants of safety performance, respondents are grouped in to three based on qualification as given below.

Low qualification - up to 10^{th} standard

Medium qualification - between 10^{th} std. and degree (+2, pre- degree, ITI, diploma etc.)

High qualification - degree and above

The effects of qualification on determinants of safety performance were studied using one-way ANOVA test. Initially, all groups were taken together and the null hypothesis H_0 was tested.

H_0: There is no significant difference between the groups with respect to determinants of safety performance.

The results are presented in Table 5.5. The results indicate that there is significant difference between groups with respect to both KNO and MOT. Hence, the null hypothesis (H_0) was rejected and the alternate hypothesis proposing significant difference between the groups was accepted. Figure 5.1 shows the mean scores of KNO and MOT for the 3 groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

H_{01}: There is no significant difference between low and medium qualification groups with respect to determinants of safety performance.

H_{02}: There is no significant difference between medium and high qualification groups with respect to determinants of safety performance.

H_{03}: There is no significant difference between high and low qualification groups with respect to determinants of safety performance.

Table 5.5 Difference in the levels of determinants of safety performance with respect to qualification. Results of ANOVA: (all groups taken together)

Deter-minants	Low		Medium		High		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
KNO	3.865	0.671	3.894	0.541	4.110	0.466	17.629	0.000 **
MOT	4.395	0.539	4.470	0.459	4.553	0.387	10.977	0.000 **

** indicate $p < 0.01$

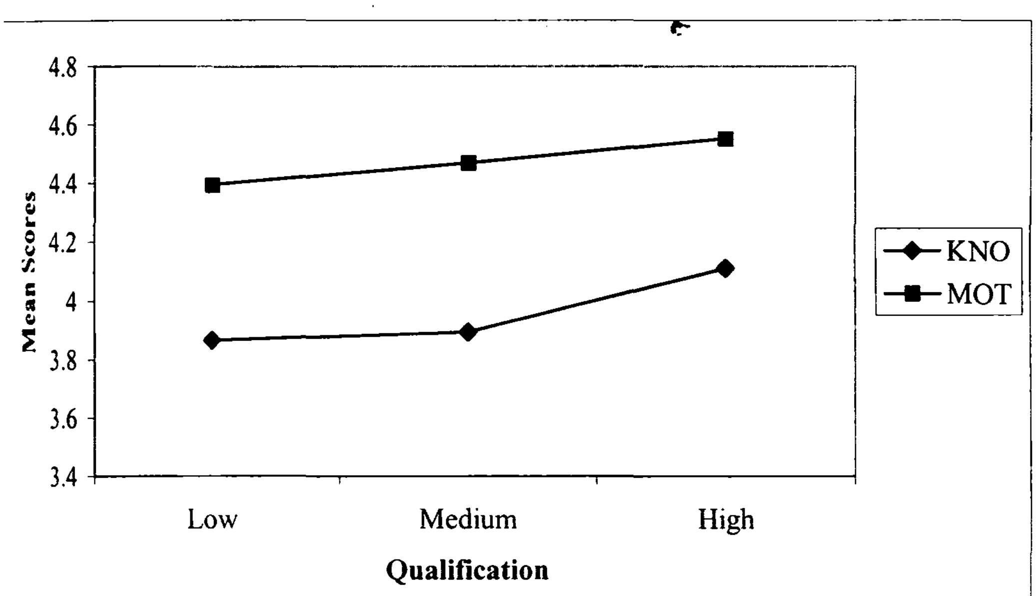

Figure 5.1 Determinants of Safety performance Vs Qualification

These three hypotheses were tested separately for each of the dependent variables (KNO and MOT) and the results are presented in Table 5.6. The following observations are drawn from the above results.

Table 5.6 Impact of Qualification on Safety Knowledge (KNO) and Safety Motivation (MOT). Comparison of determinants of safety performance between groups- ANOVA results: (taken two at a time)

Determinants of safety performance	Low Vs Medium		Medium Vs High		High Vs Low	
	F - value	p - value	F - value	p - value	F - value	p - value
KNO	0.900	0.343 ns	34.130	0.000 **	29.241	0.000 **
MOT	8.764	0.003 **	6.986	0.008 **	18.501	0.000 **

** indicates $p < 0.01$ ns - non-significant

Low and medium qualification groups do not differ significantly with respect to KNO indicating that the two groups have same level of Safety Knowledge. But the two groups differ significantly with respect to MOT indicating that medium qualification group has significantly higher level of Safety Motivation compared to low qualification group. Hence hypothesis ($H_{0.1}$) gained only partial support.

Medium and high qualification groups differ significantly with respect to both KNO and MOT. High qualification group possess better Safety Knowledge and Safety Motivation compared with medium qualification group. Hence, hypothesis ($H_{0.2}$) was rejected accepting the alternate hypothesis proposing that the two groups differ significantly with respect to determinants of safety performance.

High and low qualification groups also differ significantly with respect to both KNO and MOT rejecting hypothesis ($H_{0.3}$). From the above results, it is concluded that, qualification of employees influence both Safety Knowledge and Safety Motivation. Graduates have significantly higher Safety Knowledge compared with others whereas Safety Motivation increases with qualification. Thus, in practice, supervisors and first line officers can utilize this better safety knowledge of graduate employees in safety awareness programmes, participatory activities and training purposes by encouraging and supporting them.

5.3.4.2 Impact of age on determinants of safety performance

To study the relationship between age of employees and determinants of safety performance, respondents were grouped in to three classes based on age as given below.

Low age group - Age up to 35 years

Medium age group - Age between 36 and 50 years

High age group - Age above 50 years

The effects of age on determinants of safety performance were studied using one-way ANOVA. Initially, all groups were taken together and the null hypothesis H_0 was tested.

H_0: There is no significant difference between the groups with respect to determinants of safety performance.

The results are presented in Table 5.7. The results indicate that there is significant difference between the three age groups with respect to both KNO and MOT. Hence, the null hypothesis (H_0) was rejected and the alternate hypothesis proposing significant difference between the groups was accepted. Figure 5.2 shows the mean scores of KNO and MOT for the 3 age groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

H_{01}: There is no significant difference between low and medium age groups with respect to determinants of safety performance.

H_{02}: There is no significant difference between medium and high age groups with respect to determinants of safety performance.

H_{03}: There is no significant difference between high and low age groups with respect to determinants of safety performance.

Table 5.7 Difference in the levels of determinants of safety performance with respect to age. Results of ANOVA: (all groups taken together)

Deter-minants	Low (up to 35 yrs)		Medium (36-50yrs)		High (above 50yrs)		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
KNO	3.969	0.560	3.877	0.589	3.960	0.604	4.890	0.008 **
MOT	4.536	0.420	4.438	0.464	4.427	0.567	6.357	0.002 **

** indicates $p < 0.01$

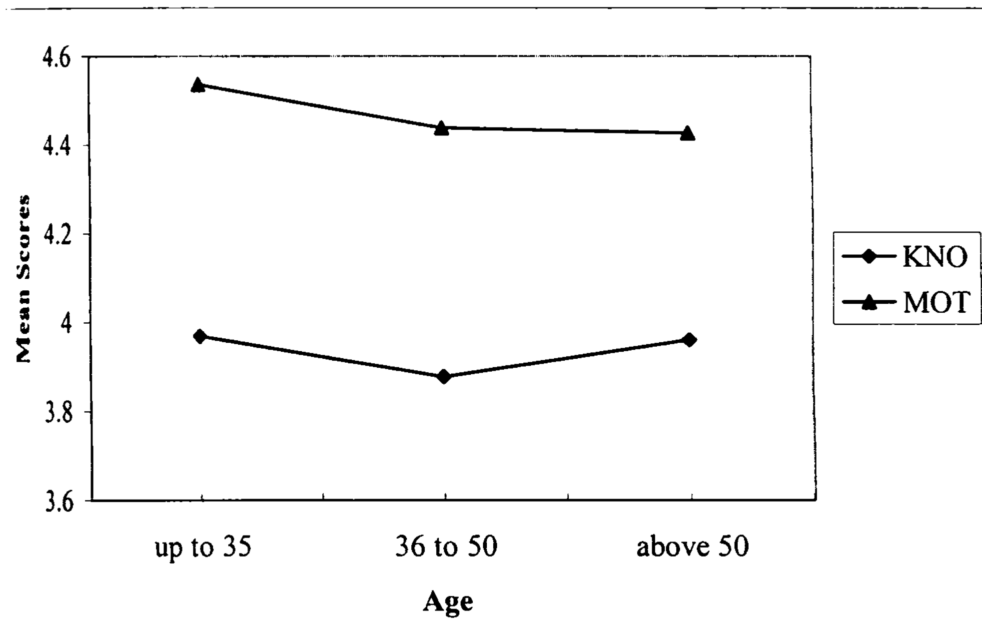

Figure 5.2 Determinants of Safety performance Vs Age

These three hypotheses were tested separately for each of the dependent variables (KNO and MOT) and the results are presented in Table 5.8. The following observations are drawn from the above results.

Table 5.8 Impact of Age on Safety Knowledge (KNO) and Safety Motivation (MOT) Comparison of determinants of safety performance between groups- ANOVA results: (taken two at a time)

Determinants of safety performance	Low Vs Medium		Medium Vs High		High Vs Low	
	F - value	p - value	F - value	p - value	F - value	p - value
KNO	6.560	0.011 *	5.870	0.016 *	0.040	0.841 ns
MOT	12.400	0.000 **	0.134	0.715 ns	8.895	0.003 **

** indicates $p < 0.01$ ns - non-significant

Low and medium age groups differ significantly with respect to both KNO and MOT indicating that the two groups have different levels of Safety Knowledge and Safety Motivation. Hence hypothesis ($H_{0.1}$) was rejected and the alternate hypothesis proposing significant difference between these 2 groups with respect to determinants of safety performance was accepted. It is interesting to note that medium age group has lower levels of both KNO and MOT compared with low age group.

Medium and high age groups differ significantly with respect to KNO, whereas they possess same level of MOT. Hence hypothesis ($H_{0.2}$) gained only partial support. High age group possess better Safety Knowledge compared with medium age group.

High and low age groups differ significantly with respect to only Safety Motivation but have same levels of Safety Knowledge. Therefore, hypothesis ($H_{0.3}$) was partially accepted. From the above results, it is concluded that, age of employees influence both Safety Knowledge and Safety Motivation. Safety Knowledge decreases with increase in age first and then increases, as they grow older. Safety Motivation decreases first and remains almost constant thereafter.

Diaz et al. (1997) observed that younger people have a more positive safety attitude and this could be the result of higher familiarization and adaptation to risk by younger workers. This matches with the present findings.

These findings contradict that of Siu et al. (2003), Frone (1998), Kingsma (1994), Stalneker (1998) and Topf (2000) who concluded that older workers have more safety knowledge and motivation than younger counterparts. However, Czaja (2001) has reported that information regarding aging and work performance is limited, and the information that is available is somewhat contradictory. This research point out that, continuous retraining and motivational efforts are to be initiated from the management side to improve the situation in the industrial units studied.

5.3.4.3 Impact of tenure on determinants of safety performance

To study the relationship between years of experience of employees and determinants of safety performance, respondents were grouped in to three based on years of experience as given below.

Low tenure group - Tenure up to 10 years
Medium tenure group - Tenure between 11 and 20 years
High tenure group - Tenure above 20 years

The effects of tenure on determinants of safety performance are studied using one-way ANOVA test. Initially, all groups are taken together and the null hypothesis H_0 is tested.

H_0: There is no significant difference between the groups with respect to determinants of safety performance.

The results are presented in Table 5.9. The results indicate that there is significant difference between the three tenure groups with respect to both KNO and MOT. Hence, the null hypothesis (H_0) was rejected and the alternate hypothesis proposing significant difference between the groups was accepted. Figure 5.3 shows the mean scores of KNO and MOT for the 3 tenure groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

Table 5.9 Difference in the levels of determinants of safety performance with respect to tenure. Results of ANOVA: (all groups taken together)

Deter-minants	Low (up to 10yrs)		Medium (11-20 yrs)		High (above 20 yrs)		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
KNO	3.975	0.553	3.860	0.589	3.948	0.603	6.574	0.001 **
MOT	4.523	0.436	4.422	0.495	4.456	0.492	5.629	0.004 **

** indicate $p < 0.01$

H_{01}: There is no significant difference between low and medium tenure groups with respect to determinants of safety performance.

H_{02}: There is no significant difference between medium and high tenure groups with respect to determinants of safety performance.

H_{03}: There is no significant difference between high and low tenure groups with respect to determinants of safety performance.

These three hypotheses were tested separately for each of the dependent variables (KNO and MOT) and the results are presented in Table 5.10. The following observations are drawn from the above results.

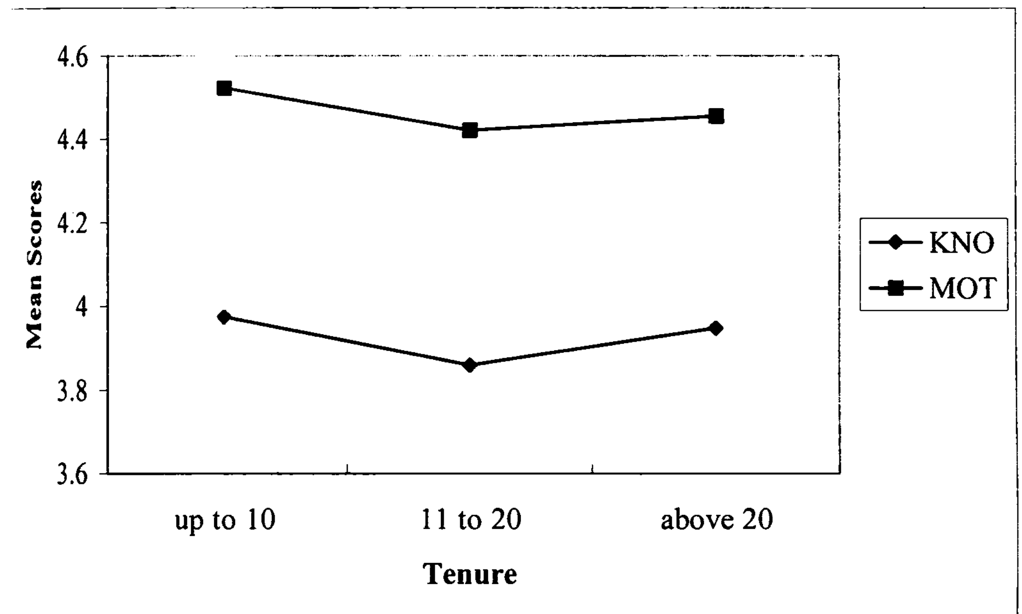

Figure 5.3 Determinants of Safety performance Vs Tenure

Low and medium tenure groups differ significantly with respect to both KNO and MOT indicating that the two groups have different levels of Safety Knowledge and Safety Motivation. Hence hypothesis ($H_{0.1}$) was rejected and the alternate hypothesis proposing significant difference between these 2 groups with respect to determinants of safety performance was accepted. It is interesting to note that medium tenure group has lower levels of both KNO and MOT compared with low tenure group.

Table 5.10 Impact of Tenure on Safety Knowledge (KNO) and Safety Motivation (MOT) Comparison of determinants of safety performance between groups- ANOVA results: (taken two at a time)

Determinants of safety performance	Low Vs Medium		Medium Vs High		High Vs Low	
	F - value	p - value	F - value	p - value	F - value	p - value
KNO	10.259	0.001 **	7.781	0.005 **	0.492	0.483 ns
MOT	11.504	0.001 **	1.681	0.195 ns	4.679	0.031 *

** indicates p < 0.01 * indicates p < 0.05 ns – non-significant

Medium and high tenure groups differ significantly with respect to KNO, whereas they possess same level of MOT. Hence hypothesis ($H_{0.2}$) gained only partial support. High tenure group possess better Safety Knowledge compared with medium tenure group.

High and low tenure groups differ significantly with respect to only Safety Motivation but have same levels of Safety Knowledge. Therefore, hypothesis ($H_{0.3}$) was partially accepted. From the above results, it is concluded that, tenure of employees influence both Safety Knowledge and Safety Motivation. Safety Knowledge seems to decrease with tenure first and then increase as they grow older. Safety Motivation decreases first and remains almost constant thereafter.

It is observed from this study that age and tenure have identical relationships with determinants of safety performance. In the social set-up in Kerala, where getting a job in a company itself is a huge privilege, people seldom change their jobs. This is evident from the high correlation ($r = 0.86$, $p < 0.001$) obtained between age and years of experience in the company.

Mearns et al. (2003) have reported that employees' involvement in safety and health activities increase with tenure. Present study however does not support this argument.

5.3.4.4 Impact of job category on determinants of safety performance

To study the relationship between job category and determinants of safety performance, respondents were grouped into supervisory staff and workmen. Out of 1806 responses obtained, 240 were supervisors and the remaining1566 were workmen. The effects of job category on determinants of safety performance were studied using one-way ANOVA test. To find whether the two groups differ with respect to determinants of safety performance, the null hypothesis H_0 was tested.

H_0: There is no significant difference between the groups with respect to determinants of safety performance.

The results are presented in Table 5.11. The results indicate that there is significant difference between supervisors and workmen with respect to both KNO and MOT.

Hence, the null hypothesis (H_0) was rejected and the alternate hypothesis proposing significant difference between them has been accepted.

Table 5.11 Difference in the levels of determinants of safety performance with respect to job category. Results of ANOVA.

Deter-minants	Supervisors		Workmen		F value	p value
	Mean	SD	Mean	SD		
KNO	4.083	0.495	3.888	0.597	23.191	0.000 **
MOT	4.527	0.446	4.443	0.488	6.191	0.013 *

** indicates $p < 0.01$ * indicates $p < 0.05$

The higher level of KNO and MOT of supervisors than workers can be justified because they are the people directly responsible for employee behaviour and performance with regards to safety. It is well accepted that only knowledgeable and motivated supervisor can motivate workers under them.

5.3.4.5 Impact of accident history on determinants of safety performance

To study the relationship between accident history of employees and determinants of safety performance, respondents were grouped in to post-traumatic and pre-traumatic groups. The effects accident history on determinants of safety performance are studied using one-way ANOVA test. To find whether the two groups differ with respect to determinants of safety performance, the null hypothesis H_0 was tested.

H_0: There is no significant difference between the groups with respect to determinants of safety performance.

The results are presented in Table 5.12. The results indicate that there is significant difference between post-traumatic and pre-traumatic groups with respect to KNO only. The two groups have same level of MOT. Hence, the null hypothesis (H_0) was partially accepted.

Table 5.12 Difference in the levels of determinants of safety performance with respect to accident history. Results of ANOVA.

Deter-minants	Accident- "yes"		Accident- "no"		F value	p value
	Mean	SD	Mean	SD		
KNO	3.827	0.629	3.964	0.558	22.942	0.000 **
MOT	4.452	0.494	4.456	0.478	0.032	0.857 ns

** indicates $p < 0.01$ ns – non-significant

Sherry (1991) had found in his studies that several dimensions on safety attitude questionnaire can distinguish between employees who had sustained injuries and those who had not. This matches with the present studies where it is observed that those who had met with accidents do have lower level of Safety Knowledge and Safety Motivation.

5.3.5 Impact of management system certification on determinants of safety performance

To analyze the impact of system certification on determinants of safety performance, the firms were classified into system certified and non-certified firms. The system certified firms were further divided into OHSAS certified, ISRS certified and ISO certified firms as explained earlier in Chapter 4. The effects of system certification on determinants of safety performance were studied using one-way ANOVA test. Initially the responses were tested to find out whether there is any significant difference among the groups using ANOVA with all groups taken together. The null hypothesis to be tested was:

H_0: There is no significant difference between the groups with respect to determinants of safety performance

The results are presented in Table 5.13. The results indicate that there is significant difference (at 0.01 significance level) between groups with respect to both Safety Knowledge and Safety Motivation. Hence, the null hypothesis (H_0) was not supported. Figure 5.4 shows the mean scores of the two determinants of safety performance for the four groups for a comparative study. Therefore, for further investigation, the different categories of firms were tested to find whether there is any significant difference between

...e groups with respect to the determinants of safety performance, with two categories ...en at a time. The following null hypotheses ($H_{0.1}$ to $H_{0.7}$) were tested using ANOVA.

...le 5.13 Difference in the levels of determinants of safety performance with respect to system certification. Results of ANOVA: (all groups taken together)

Deter-minant	OHSAS-certified		ISRS-certified		ISO-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
KNO	4.100	0.444	4.111	0.476	3.873	0.624	3.840	0.597	20.80	0.000**
MOT	4.544	0.474	4.586	0.364	4.417	0.470	4.422	0.521	10.82	0.000**

** indicates $p < 0.01$

- There is no significant difference between certified firms and non-certified firms with respect to determinants of safety performance.
- There is no significant difference between OHSAS-certified firms and non-certified firms with respect to determinants of safety performance.
- There is no significant difference between ISRS-certified firms and non-certified firms with respect to determinants of safety performance.
- There is no significant difference between ISO-certified firms and non-certified firms with respect to determinants of safety performance.
- There is no significant difference between OHSAS-certified firms and ISRS-certified firms with respect to determinants of safety performance.
- There is no significant difference between OHSAS-certified firms and ISO-certified firms with respect to determinants of safety performance.
- There is no significant difference between ISRS-certified firms and ISO-certified firms with respect to determinants of safety performance.

...se seven hypotheses were tested separately for each of the dependent variables (KNO ...d MOT). The results are presented in Table 5.14.

...e difference between non-certified firms and certified firms is significant ($p < 0.05$) ...h respect to both KNO and MOT. Hence, the null hypothesis $H_{0.1}$ was rejected. It is ...nd that the certified firms have better scores in Safety Knowledge and Safety ...tivation compared with non-certified firms.

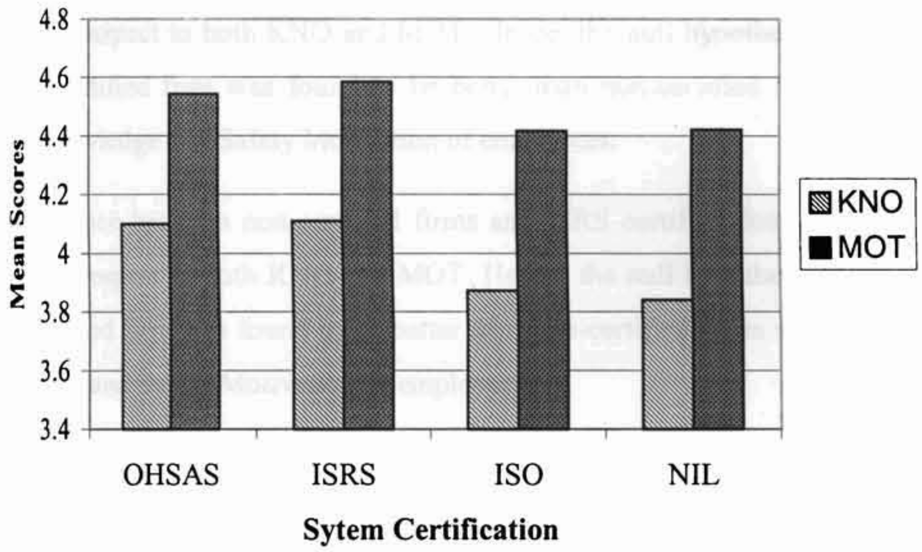

Figure 4 System Certification Vs Determinants of Safety Performance

Table 5.14 Impact of system certification on Safety Knowledge (KNO) and Safety Motivation (MOT). Comparison of determinants of safety performance between groups- ANOVA results: (taken two at a time)

Groups	Safety Knowledge (KNO)		Safety Motivation (MOT)	
	F - value	p - value	F - value	p - value
Certified Vs Non-certified	20.249	0.000 **	5.834	0.016 *
OHSAS-certified Vs Non-certified	28.302	0.000 **	7.794	0.005 **
ISRS-certified Vs Non-certified	43.250	0.000 **	21.662	0.000 **
ISO-certified Vs Non-certified	0.975	0.324 ns	0.036	0.849 ns
OHSAS-certified Vs ISRS-certified	0.061	0.805 ns	1.049	0.306 ns
OHSAS-certified Vs ISO-certified	19.657	0.000 **	9.731	0.002 **
ISRS-certified Vs ISO-certified	30.265	0.000 **	26.648	0.000 **

** indicates $p < 0.01$, ns – non-significant

The difference between non-certified firms and OHSAS certified firm is significant ($p < 0.01$) with respect to both KNO and MOT. Hence, the null hypothesis $H_{0.2}$ was rejected. OHSAS certified firm was found to be better than non-certified firms with respect to Safety Knowledge and Safety Motivation of employees.

The difference between non-certified firms and ISRS certified firms is significant ($p < 0.01$) with respect to both KNO and MOT. Hence, the null hypothesis $H_{0.3}$ was rejected. ISRS certified firm was found to be better than non-certified firms with respect to Safety Knowledge and Safety Motivation of employees.

The difference between non-certified firms and ISO certified firms is not significant with respect to both KNO and MOT. Hence, the null hypothesis $H_{0.4}$ was supported. This indicates that the levels of Safety Knowledge and Safety Motivation of employees are similar in ISO certified firms and non-certified firms.

The difference between ISRS certified firms and OHSAS certified firms is not significant with respect to both KNO and MOT. Hence, the null hypothesis $H_{0.5}$ was supported. This indicates that the levels of Safety Knowledge and Safety Motivation of employees are similar in OHSAS certified firms and ISRS certified firms.

The difference between ISO certified firms and OHSAS certified firms is significant ($p < 0.01$) with respect to both KNO and MOT. Hence, the null hypothesis $H_{0.6}$ was rejected. OHSAS certified firm was found to be better than ISO certified firms with respect to Safety Knowledge and Safety Motivation of employees.

The difference between ISRS certified firms and ISO certified firms was significant ($p < 0.01$) with respect to both KNO and MOT. Hence, the null hypothesis $H_{0.7}$ was rejected. ISRS certified firm was found to be better than ISO certified firms with respect to Safety Knowledge and Safety Motivation of employees.

From the above findings, it can be inferred that the system certified firms have better safety management practices to create better Safety Knowledge and Safety Motivation among the employees. However, in ISO certified firms, these efforts are not sufficient enough compared with OHSAS certified and ISRS certified firms, and the safety awareness of the employees remains at par with non-certified firms. This is because, even though safety means quality (Carder and Ragan, 2003), and the regulations based on ISO 9001 have been created to guide companies in developing systems for management and the prevention of worker risks (Herrero et al., 2002), it warrants extra commitment from the management to channel the efforts for safe guarding their employees. Managements tend to neglect this, as the cost – benefit aspect do not appear very attractive in short-term. OHSAS certified and ISRS certified firms are found to have similar levels of Safety Knowledge and Safety Motivation among the employees.

To be more specific, it is concluded that OHSAS certified and ISRS certified firms are better than ISO certified and non-certified firms, with respect to the determinants of safety performance, KNO and MOT.

5.3.6 Impact of accidents on determinants of safety performance

To study the impact of accident rates on determinants of safety performance, organizations were grouped on the basis of self-reported accident rates as low, medium and high accident groups. The effects of accident rate on determinants of safety performance were studied using one-way ANOVA test. Initially the responses were tested to find out whether there is any significant difference among the groups using ANOVA with all groups taken together. The null hypothesis to be tested was:

H_0: There is no significant difference between groups with respect to determinants of safety performance.

The results of ANOVA test are presented in Table 5.15. It is evident from "F" and "p" values that there is significant difference between the groups and hence the null hypothesis was rejected and the alternate hypothesis stating that the groups differ significantly with respect to determinants of safety performance was accepted. Figure 5.5 shows the mean scores of KNO and MOT for the 3 accident groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

Table 5.15 Difference in the levels of determinants of safety performance with respect to accidents. Results of ANOVA: (all groups taken together)

Deter-minants	Low		Medium		High		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
KNO	4.107	0.463	3.868	0.595	3.828	0.637	31.406	0.000 **
MOT	4.569	0.411	4.408	0.489	4.444	0.517	16.708	0.000 **

** indicates $p < 0.01$

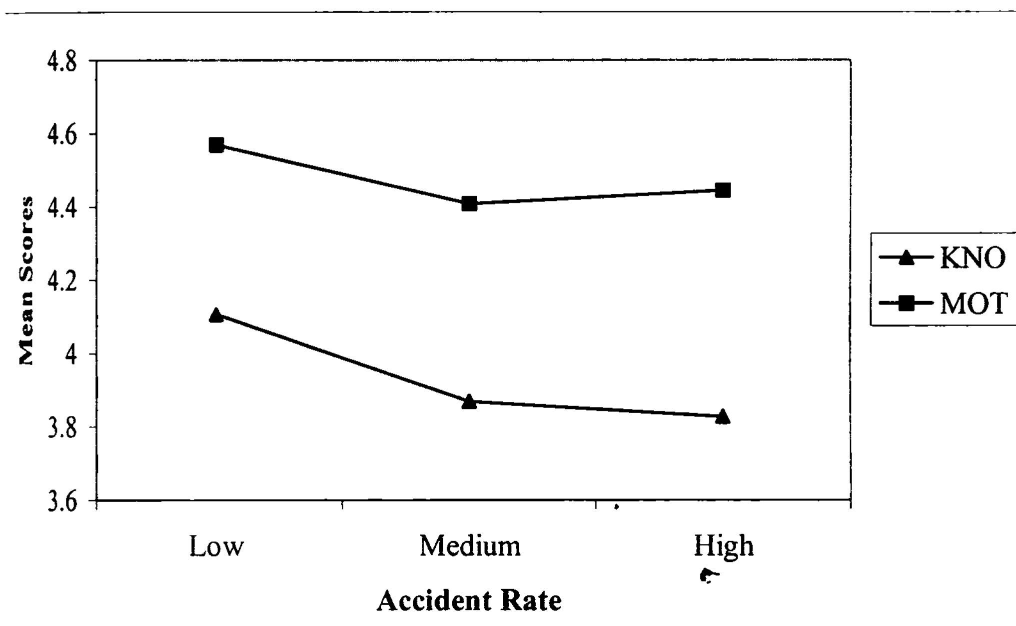

Figure 5.5 Accidents Vs Determinants of Safety performance

H_{01}: There is no significant difference between low and medium accident groups with respect to determinants of safety performance.

H_{02}: There is no significant difference between medium and high accident groups with respect to determinants of safety performance.

H_{03}: There is no significant difference between high and low accident groups with respect to determinants of safety performance.

These three hypotheses were tested separately for each of the dependent variables (KNO and MOT) and the results are presented in Table 5.16. The following observations are made from the above results:

Table 5.16 Impact of accidents on Safety Knowledge (KNO) and Safety Motivation (MOT). Comparison of determinants of safety performance between groups- ANOVA results: (taken two at a time)

Determinants of safety performance	Low Vs Medium		Medium Vs High		High Vs Low	
	F - value	p - value	F - value	p - value	F - value	p - value
KNO	53.301	0.000 **	1.346	0.246 ns	54.106	0.000 **
MOT	34.993	0.000 **	1.594	0.207 ns	15.587	0.000 **

** indicates $p < 0.01$, ns – non-significant

The levels of KNO and MOT are significantly lower in medium accident rate organizations compared with low accident rate organizations. Hence, null hypothesis ($H_{0.1}$) was rejected

Medium and high accident rate organizations have same levels of KNO and MOT and hence hypothesis ($H_{0.2}$) was accepted. High and low accident rate organizations differ significantly with respect to both KNO and MOT, rejecting hypothesis ($H_{0.3}$).

Organizations with higher rates of self-reported accidents are characterized by lower levels of Safety Knowledge and Safety Motivation among their employees.

5.4 IDENTIFICATION OF COMPONENTS OF SAFETY PERFORMANCE

The components of safety performance represent the major dimensions of task-relevant behaviours involved in a given job. Based on survey of literature on safety performance and discussions with experienced safety professionals in industries and management experts from academics, two components of safety performance have been identified. They are Safety Compliance (COM) and Safety Participation (PAR).

5.4.1 Safety Compliance

Safety compliance involves adhering to safety procedures and carrying out work in a safe manner. Burke et al. (2002) have measured safety performance in terms of compliance to specific safety rules and instructions and found positive relationship with safety knowledge specific to these dimensions. Smith-Crowe et al. (2003) measured safety performance in hazardous work environments in terms of compliance to safety rules and found the scale possessed high reliability. Thompson et al. (1998) used self-reported compliance as a safety performance indicator in building a model that links management support, organizational climate and self-reported safety outcome. Lee and Harrison (2000) used nine self-reported performance measures including compliance to safety in their study to establish relationship with safety climate factors. Neal et al. (2000) tested a series of hypotheses connecting determinants and components of safety performance and testified the positive relationship between Safety Knowledge and Safety Compliance. From the above studies, it is concluded that Safety Compliance can be considered as a component of safety performance.

5.4.2 Safety Participation

Safety Participation involves helping co-workers, promoting the safety programme within the workplace, demonstrating initiative, and putting effort into improving safety in the workplace. Such a behavioural change occurs only when the employees also develops a commitment for safety similar to the management commitment for safety. The various management practices targeting continuous improvement in safety inculcate a belief among the employees that they are not outside, but very much inside the management mainstream as far as safety and health matters are concerned. This brings in a sense of responsibility and commitment, and will be expressed in behaviour for promoting safety. Personal involvement in safety was included in the workplace safety measurement questionnaire used by Silva et al. (2004). Co-worker support and participation with others were used by DeJoy et al. (2004) in Organizational climate scale for measuring safety performance. Hayes et al. (1998) found that co-worker safety has negative correlation with different types of accident rates, and positive correlation with management practices, in the validation phase of his safety measurement studies. Neal et al. (2000) included Safety Participation as a component of safety performance and tested a series of hypotheses connecting determinants and components of safety performance using structural equation modelling and revealed significant relationships. From the above studies, it is concluded that Safety Participation can be considered as a component of safety performance.

5.5 VALIDATION OF THE INSTRUMENT: DATA COLLECTION, ANALYSIS, RESULTS AND DISCUSSION

5.5.1 Methodology and Validation of the Instrument

Data was collected through the same instrument referred in Chapter 3, which was used to measure the safety management practices. Twelve questions were included to measure the two components of safety performance, namely, Safety Compliance and Safety Participation (see Appendix). The content validity and face validity have been assured in the initial stages of the questionnaire development. Eight items were phrased positively and the remaining four negatively. The unidimensionality and validity of this instrument have been tested by running confirmatory factor analysis using AMOS-4 software and reliability was assessed using SPSS-10. The results are presented in Table 5.17. Four items, three from Safety Compliance and one from Safety Participation were removed from the scale due to low item-total correlations.

It can be seen that both the measures exhibit strong unidimensionality (CFI greater than 0.9), convergent validity (TLI greater than 0.9) and reliability (Cronbach's alpha (α) greater than 0.6).

Table 5.17. Results of Confirmatory Factor Analysis: Unidimensionality, Convergent Validity and Reliability coefficients for components of safety performance

Sl No	Components of safety performance	No.of items	Comparative Fit Index (CFI)	Cronbach's Alpha (α)	Tucker-Lewis Index (TLI)
1	Safety Compliance (COM)	4	0.997	0.763	0.990
2	Safety Participation (PAR)	4	0.982	0.657	0.947
	Overall	8	0.963	-	0.943

5.5.2 Bivariate correlation between the independent and dependent variables

The bivariate correlation between the independent variables and the dependent variable was tested using the responses. SPSS 10 software was used for this purpose. The results are presented in Table 5.18. Each components of safety performance is positively correlated to determinants of safety performance at significance level beyond 0.01, thereby indicating that these measures are strong predictors of the dependent variable.

Table 5.18 Bivariate Correlations among the safety performance components and the two determinants of safety performance

	Mean	S.D.	KNO	MOT	COM	PAR
KNO	3.914	0.588	1.00			
MOT	4.454	0.483	0.415**	1.00		
COM	3.876	0.698	0.652**	0.386**	1.00	
PAR	3.798	0.612	0.517**	0.433**	0.600**	1.00

5.5.3 Relationship between determinants of safety performance and components of safety performance

Safety behaviour is determined by knowledge necessary for particular behaviour and by the motivation of individuals to show the behaviour. Furthermore, previous studies have revealed that knowledge and motivation have differential effects on different components of performance. It is expected that safety knowledge have a stronger relationship with compliance than with participation, while safety motivation has a stronger relationship with participation than with compliance. An individual must understand how to perform work safely and have the skill to be able to do it in order to comply with safety procedures (Neal et al., 2000). However, safety knowledge and skill are likely to be less important for participatory activities, since these activities require more generic forms of knowledge and skill (termed "tacit knowledge" by Wagner and Sternberg, 1985). Motivation is likely to be more important for participation than for compliance, because participatory activities are frequently voluntary, whereas compliance is generally mandated. Based on the above arguments, the following hypotheses were advanced:

H_{21}: Safety Knowledge and Safety Motivation predict Safety Compliance.

H_{22}: Safety Knowledge and Safety Motivation predict Safety Participation.

H_{23}: The relationship between Safety Knowledge and Safety Compliance is stronger than the relationship between Safety Knowledge and Safety Participation.

H_{24}: The relationship between Safety Motivation and Safety Participation is stronger than the relationship between Safety Motivation and Safety Compliance.

5.5.3.1 Multiple Regression Analysis

Multiple Regression Analysis was done to investigate the relationship between the determinants of safety performance (KNO and MOT) and the components of safety performance (COM and PAR), using SPSS-10 software. The determinants of safety performance were treated as predictor variables and each of the components of safety performance were treated as the dependent variable. The results are presented in Table 5.19 and Table 5.20 respectively.

The results of the 'F' statistics for the model with respect to Safety Compliance indicate that the model is significant ($p < 0.01$), and hence it can be used for explanation purposes. The R^2 value indicate that the independent variables (KNO and MOT) are together able to explain a good amount of variation in the dependent variable (Safety Compliance). From Table 5.19, it could also be inferred that the 't' statistics for both independent variables, namely KNO and MOT, have turned out to be significant ($p < 0.01$) in explaining the variation in the component of safety performance namely, Safety Compliance (COM). Hence hypothesis $H_{2.1}$ is supported.

Table 5.19 Relation between determinants of safety performance and Safety Compliance Results of Multiple Regression Analysis

Multiple R = 0.664 R^2 = 0.441	Adj. R^2 = 0.440 Std. Error = 0.522	F = 711.63 Significance 0.000 **

Factor	Beta	t	significance
KNO	0.594	30.698	0.000 **
MOT	0.139	7.199	0.000 **

** indicates $p < 0.01$

The results of the 'F' statistics for the model with respect to Safety Participation indicate that the model is significant ($p < 0.01$), and hence it can be used for explanation purposes. The R^2 value indicate that the independent variables (determinants of safety performance) are together able to explain a good percentage of variation in the dependent variable (Safety Participation). From Table 5.20, it could also be inferred that the 't' statistics for both independent variables, namely KNO and MOT, have turned out to be significant (p<

05) in explaining the variation in the component of safety performance, namely, Safety Participation (PAR). Hence hypothesis $H_{2.2}$ is supported.

Table 5.20 Relation between determinants of safety performance and Safety Participation
Results of Multiple Regression Analysis

Multiple R = 0.570 R^2= 0.325	Adj. R^2 = 0.320 Std. Error = 0.503	F = 433.65 Significance 0.000 **

Factor	Beta	t	significance
KNO	0.407	19.135	0.000 **
MOT	0.264	12.417	0.000 **

** indicates $p < 0.01$

The standardized regression coefficients (Beta coefficients) in Table 5.19 and Table 5.20 reveal that the relation between Safety Knowledge and Safety Compliance is stronger than that between Safety Knowledge and Safety Participation, supporting hypothesis $H_{2.3}$. Hypothesis $H_{2.4}$ predicted that the relationship between Safety Motivation and Safety Participation is stronger than the relationship between Safety Motivation and Safety Compliance. The standardized regression coefficients (Beta coefficients) in Table 5.19 and Table 5.20 reveal that this hypothesis was supported. Findings of this research are in tune with Neal et al. (2000) except hypothesis $H_{2.4}$ where MOT was found to have stronger relation with COM than with PAR.

5.5.4 Impact of personal attributes on components of safety performance

The weak linear relationship between determinants of safety performance (KNO and MOT) and components of safety performance (COM and PAR) presented in Table 5.19 and Table 5.20 indicate that some other variables may be influencing the components of safety performance. Hence it is decided to investigate the impact of personal variables such as qualification, age, years of experience in the organization, job category and accident history of the employee on components of safety performance. The data collected from the respondents through the demographic items of the questionnaire is used for this purpose.

5.5.4.1 Impact of qualification on components of safety performance

The effects of qualification on components of safety performance were studied using one-way ANOVA test. Initially, all groups were taken together and the null hypothesis H_0 was tested.

H_0: There is no significant difference between the groups with respect to components of safety performance.

The results are presented in Table 5.21. The results indicate that there is significant difference between groups with respect to COM. Hence, the null hypothesis (H_0) was partially accepted. Figure 5.6 shows the mean scores of COM and PAR for the 3 groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

H_{01}: There is no significant difference between low and medium qualification groups with respect to components of safety performance.

H_{02}: There is no significant difference between medium and high qualification groups with respect to components of safety performance.

H_{03}: There is no significant difference between high and low qualification groups with respect to components of safety performance.

Table 5.21 Difference in the levels of components of safety performance with respect to qualification. Results of ANOVA: (all groups taken together)

Compo-	Low		Medium		High		F	p
nents	Mean	SD	Mean	SD	Mean	SD	value	value
COM	3.870	0.760	3.851	0.654	3.975	0.676	3.194	0.041*
PAR	3.825	0.651	3.769	0.577	3.825	0.624	1.941	0.144 ns

* indicates $p < 0.05$ ns - non-significant

These three hypotheses were tested separately for each of the dependent variables (COM and PAR) and the results are presented in Table 5.22. The following observations are drawn from the above results.

Table 5.22 Impact of Qualification on Safety Compliance (COM) and Safety Participation (PAR). Comparison of components of safety performance between groups- ANOVA results: (taken two at a time)

Components of safety performance	Low Vs Medium		Medium Vs High		High Vs Low	
	F - value	p - value	F - value	p - value	F - value	p - value
COM	0.264	0.607 ns	7.073	0.008 **	3.791	0.052 ns
PAR	3.281	0.070 ns	1.863	0.173 ns	0.000	0.998 ns

** indicates $p < 0.01$ ns - non-significant

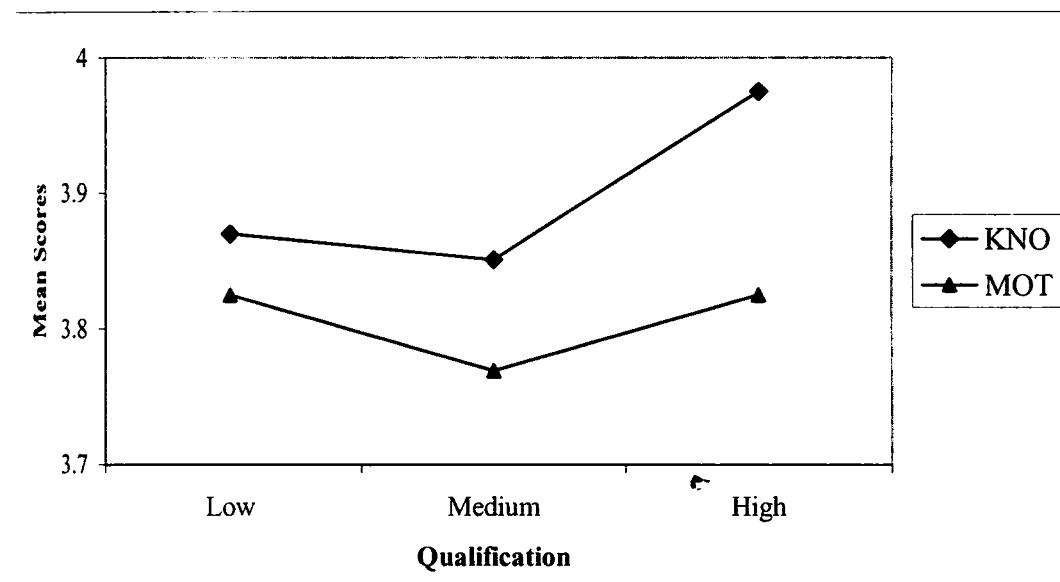

Figure 5.6 Qualification Vs Components of Safety Performance

Low and medium qualification groups do not differ significantly with respect to both COM and PAR indicating that the two groups have same level of Safety Compliance and Safety Participation. Hence, hypothesis ($H_{0.1}$) was accepted.

Medium and high qualification groups differ significantly with respect to COM only. High qualification group have better Safety Compliance compared with medium qualification group. Hence hypothesis ($H_{0.2}$) was partially accepted. High and low qualification groups have same levels of COM and PAR and hypothesis ($H_{0.3}$) was accepted. From the above results, it is concluded that, qualification of employees influence only Safety Compliance and graduates have significantly higher Safety Compliance compared with medium qualified group whereas Safety Participation remains at equal level for all groups.

5.5.4.2 Impact of age on components of safety performance

The effects of age on components of safety performance are studied using one-way ANOVA test. Initially, all 3 age groups were taken together and the null hypothesis H_0 was tested.

H_0: There is no significant difference between the age groups with respect to components of safety performance.

The results are presented in Table 5.23. The results indicate that there is significant difference between groups with respect to COM. Hence, the null hypothesis (H_0) was partially accepted. Figure 5.7 shows the mean scores of COM and PAR for the 3 groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

H_{01}: There is no significant difference between low and medium age groups with respect to components of safety performance.

H_{02}: There is no significant difference between medium and high age groups with respect to components of safety performance.

H_{03}: There is no significant difference between high and low age groups with respect to components of safety performance.

Table 5.23 Difference in the levels of components of safety performance with respect to age. Results of ANOVA: (all groups taken together)

Compo-	Up to 35 years		36 – 50 years		Above 50 years		F	p
nents	Mean	SD	Mean	SD	Mean	SD	value	value
COM	3.927	0.690	3.834	0.703	3.934	0.687	4.232	0.015 *
PAR	3.836	0.519	3.778	0.624	3.812	0.654	1.319	0.268 ns

* indicates $p < 0.05$ ns - non-significant

These three hypotheses were tested separately for each of the dependent variables (COM and PAR) and the results are presented in Table 5.24. The following conclusions can be drawn from the above results.

Table 5.24 Impact of Age on Safety Compliance (COM) and Safety Participation (PAR) Comparison of components of safety performance between groups- ANOVA results: (taken two at a time)

Groups	Safety Compliance (COM)		Safety Participation (PAR)	
	F - value	p - value	F - value	p - value
Up to 35 years Vs 36 - 50 years	4.600	0.032 *	2.439	0.119 ns
36 - 50 years Vs Above 50 years	6.062	0.014 *	0.838	0.360 ns
Above 50 years Vs Up to 35 years	0.021	0.885 ns	0.312	0.577 ns

* indicates $p < 0.05$, ns - non-significant

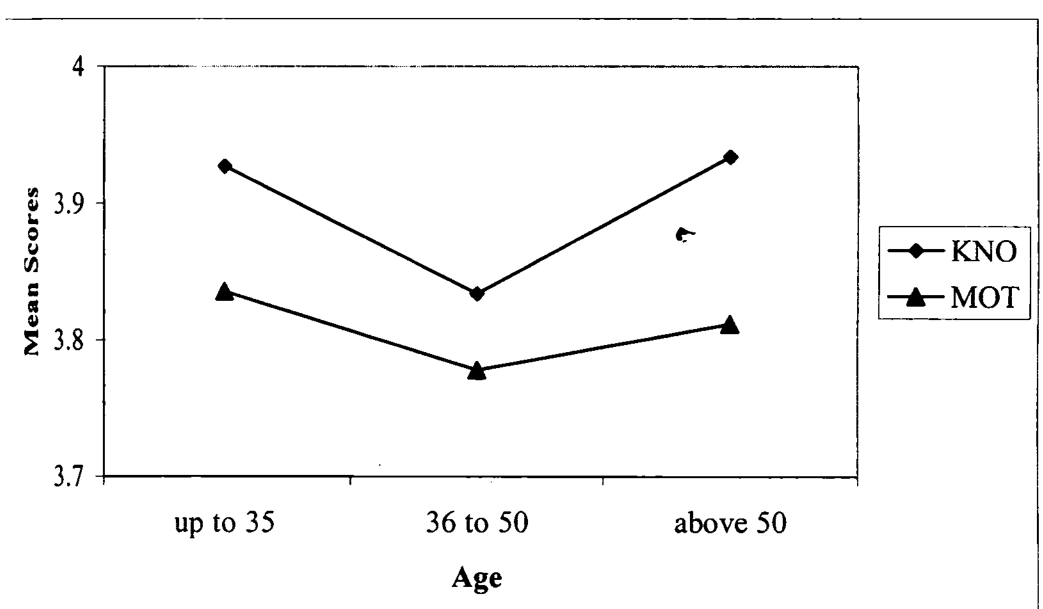

Figure 5.7 Age Vs Components of Safety Performance

Low and medium age groups differ significantly with respect to only COM and low age group has higher level of Safety Compliance. PAR has same level between the two groups. Hence, hypothesis ($H_{0.1}$) was only partially accepted. Medium and high age groups also show similar behaviour with older workers showing better Safety Compliance. Hence, hypothesis ($H_{0.2}$) was partially accepted. Hypothesis ($H_{0.3}$) was accepted since high and low age groups do not differ significantly with respect to the two components of safety performance.

In this study, it is observed that Safety Compliance decreases with increase in age first and then increase with age. This partially agrees with the findings of Diaz et al. (1997) who observed that younger people have a more positive safety attitude. There is partial agreement with Siu et al. (2003), Frone (1998), Kingsma (1994), Stalneker (1998) and Topf (2000) who concluded that older workers have more safety attitude than younger counterparts.

5.5.4.3 Impact of tenure on components of safety performance

The effects of tenure on components of safety performance were studied using one-way ANOVA test. Initially, all 3 tenure groups were taken together and the null hypothesis H_0 was tested.

H_0: There is no significant difference between the tenure groups with respect to components of safety performance.

The results are presented in Table 5.25. The results indicate that there is no significant difference between groups with respect to both COM and PAR. Hence, the null hypothesis (H_0) was accepted. Figure 5.8 shows the mean scores of COM and PAR for the 3 groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

$H_{0.1}$: There is no significant difference between low and medium tenure groups with respect to components of safety performance.

$H_{0.2}$: There is no significant difference between medium and high tenure groups with respect to components of safety performance.

$H_{0.3}$: There is no significant difference between high and low tenure groups with respect to components of safety performance.

Table 5.25 Difference in the levels of components of safety performance with respect to tenure. Results of ANOVA: (all groups taken together)

Compo-nents	Up to 10 years		11 – 20 years		Above 20 years		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
COM	3.935	0.673	3.838	0.697	3.890	0.712	2.687	0.068 ns
PAR	3.837	0.537	3.770	0.623	3.809	0.640	1.711	0.181 ns

ns - non-significant

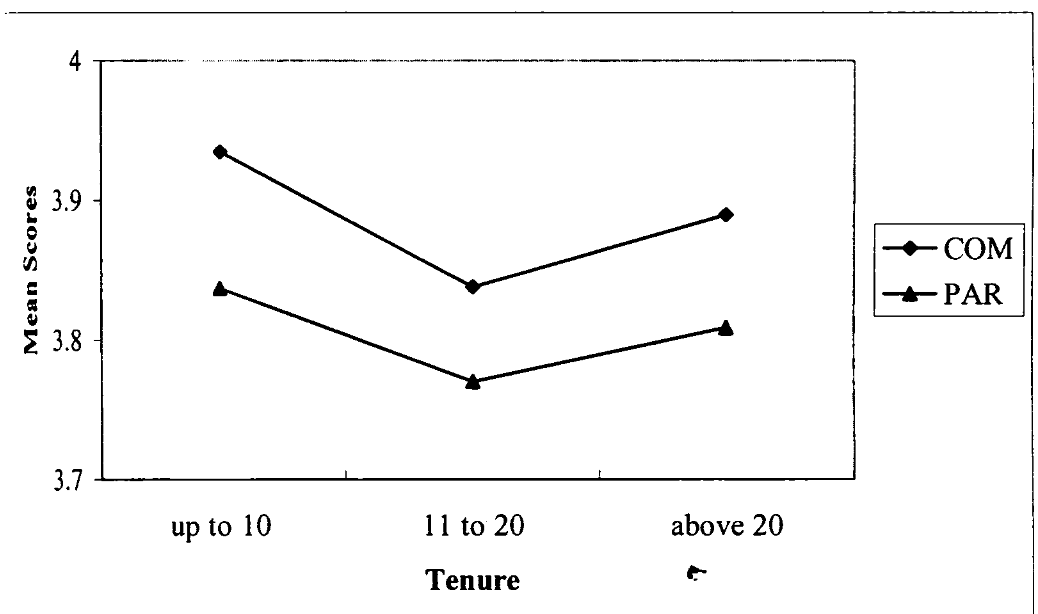

Figure 5.8 Tenure Vs Components of Safety Performance

These three hypotheses were tested separately for each of the dependent variables (COM and PAR) and the results are presented in Table 5.26. The following observations were drawn from the above results.

Low and medium tenure groups differ significantly with respect to only COM and low tenure group has higher level of Safety Compliance. PAR has same level between the two groups. Hence hypothesis ($H_{0.1}$) was only partially accepted. Medium and high tenure groups show same levels of both Safety Compliance (COM) and Safety Participation (PAR). Hence hypothesis ($H_{0.2}$) was accepted. Hypothesis ($H_{0.3}$) is also accepted since

gh and low tenure groups do not differ significantly with respect to the two components
f safety performance.

able 5.26 Impact of Tenure on Safety Compliance (COM) and Safety Participation (PAR). Comparison of components of safety performance between groups ANOVA results: (taken two at a time)

roups	Safety Knowledge (KNO)		Safety Motivation (MOT)	
	F - value	p - value	F - value	p - value
p to 35 years Vs 6 - 50 years	5.129	0.024 *	3.225	0.073 ns
6 - 50 years Vs bove 50 years	1.893	0.169 ns	1.365	0.243 ns
bove 50 years Vs p to 35 years	1.004	0.317 ns	0.487	0.485 ns

* indicates $p < 0.05$, ns - non-significant

u et al. (2003) has reported that workers with longer working experience show more ompliance to safety rules. The present study however show that, as tenure increase, afety Compliance reduce and then remain almost constant with further increase in enure. Safety Participation seems to have no relationship with tenure.

5.4.4 Impact of job category on components of safety performance

he effects of job category on components of safety performance were studied using one-ay ANOVA test. To find whether the two groups differ with respect to components of afety performance, the null hypothesis H_0 was tested.

: There is no significant difference between the groups with respect to components of safety performance.

he results are presented in Table 5.27. The results indicate that there is no significant ifference between supervisors and workmen with respect to both COM and PAR. ence, the null hypothesis (H_0) was accepted.

Table 5.27 Difference in the levels of components of safety performance with respect to job category. Results of ANOVA.

Components	Supervisors		Workmen		F value	p value
	Mean	SD	Mean	SD		
COM	3.933	0.712	3.867	0.696	1.888	0.170 ns
PAR	3.848	0.609	3.790	0.613	1.880	0.171 ns

ns - non-significant

5.5.4.5 Impact of accident history on components of safety performance

The effects accident history on components of safety performance were studied using one-way ANOVA test. To find whether the two groups differ with respect to components of safety performance, the null hypothesis H_0 was tested.

H_0: There is no significant difference between the groups with respect to components of safety performance.

The results are presented in Table 5.28. The results indicate that there is significant difference between post-traumatic and pre-traumatic groups with respect to both COM and PAR. Hence, the null hypothesis (H_0) was rejected.

Table 5.28 Difference in the levels of components of safety performance with respect to accident history. Results of ANOVA.

Components	Accident- "yes"		Accident- "no"		F value	p value
	Mean	SD	Mean	SD		
COM	3.749	0.721	3.948	0.675	34.393	0.000 **
PAR	3.735	0.650	3.833	0.587	10.820	0.001**

** indicates $p < 0.01$

Those who have experienced accidents while working show less compliance to safety rules and less participation in safety activities.

5.5.5 Impact of management system certification on components of safety performance

To analyze the impact of management system certification on components of safety performance, the firms were classified into system certified and non-certified firms. The system certified firms were further divided into OHSAS certified, ISRS certified and ISO certified firms as explained in Chapter 4. The effects of system certification on components of safety performance were studied using one-way ANOVA test. Initially, the responses were tested to find out whether there is any significant difference among the groups using ANOVA with all groups taken together. The null hypothesis to be tested was:

H_0: There is no significant difference between the groups with respect to components of safety performance

The results are presented in Table 5.29. The results indicate that there is significant difference (at 0.01 significance level) between groups with respect to both Safety Compliance and Safety Participation. Hence, the null hypothesis (H_0) was not supported. Figure 5.9 shows the mean scores of the two components of safety performance for the four groups for a comparative study. Therefore, for further investigation, the different categories of firms were tested to find whether there is any significant difference between the groups with respect to the components of safety performance, with two categories taken at a time. The following null hypotheses ($H_{0.1}$ to $H_{0.7}$) were tested using ANOVA.

Table 5.29 Difference in the levels of components of safety performance with respect to system certification. Results of ANOVA: (all groups taken together)

Comp-onents	OHSAS-certified		ISRS-certified		ISO-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
COM	4.092	0.580	4.200	0.549	3.825	0.701	3.759	0.722	33.50	0.000**
PAR	3.933	0.545	3.939	0.529	3.759	0.614	3.751	0.641	9.690	0.000**

** indicates $p < 0.01$

$H_{0.1}$: There is no significant difference between certified firms and non-certified firms with respect to components of safety performance.

$H_{0.2}$: There is no significant difference between OHSAS-certified firms and non-certified firms with respect to components of safety performance.

$H_{0.3}$: There is no significant difference between ISRS-certified firms and non-certified firms with respect to components of safety performance.

$H_{0.4}$: There is no significant difference between ISO-certified firms and non-certified firms with respect to components of safety performance.

$H_{0.5}$: There is no significant difference between OHSAS-certified firms and ISRS-certified firms with respect to components of safety performance.

$H_{0.6}$: There is no significant difference between OHSAS-certified firms and ISO-certified firms with respect to components of safety performance.

$H_{0.7}$: There is no significant difference between ISRS-certified firms and ISO-certified firms with respect to components of safety performance.

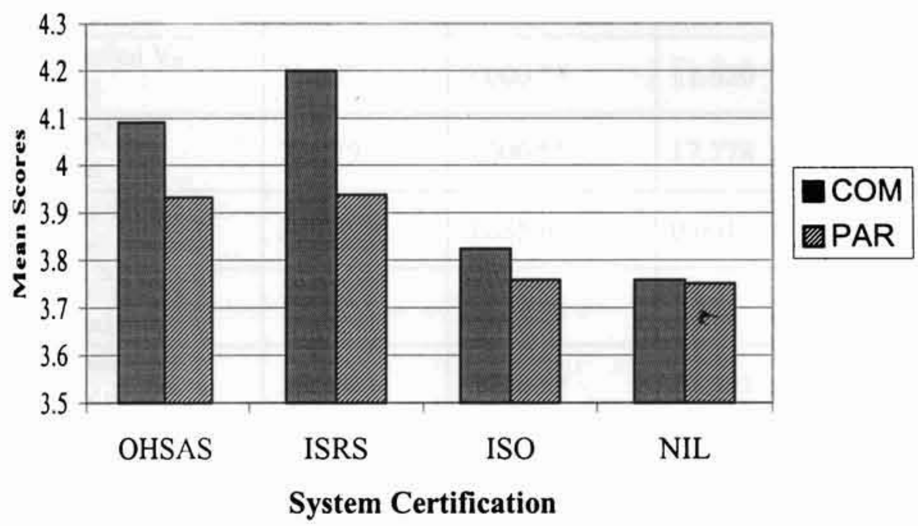

Figure 5.9 Components of Safety Performance Vs System Certification

These seven hypotheses were tested separately for each of the dependent variables (COM and PAR). The results are presented in Table 5.30.

The difference between non-certified firms and certified firms is significant ($p < 0.01$) with respect to both COM and PAR. Hence the null hypothesis $H_{0.1}$ was rejected. It is found that the certified firms indicate better scores in Safety Compliance and Safety Participation compared with non-certified firms.

The difference between non-certified firms and OHSAS certified firms is significant ($p < 0.01$) with respect to both COM and PAR. Hence the null hypothesis $H_{0.2}$ was rejected. This indicates that the level of Safety Compliance and Safety Participation of employees is higher in OHSAS certified firms than in non-certified firms.

Table 5.30 Impact of system certification on Safety Compliance (COM) and Safety Participation (PAR). Comparison of determinants of safety performance between groups- ANOVA results: (taken two at a time)

Groups	Safety Compliance(COM)		Safety Participation(PAR)	
	F - value	p - value	F - value	p - value
Certified Vs Non-certified	36.087	0.000 **	7.228	0.007 **
OHSAS-certified Vs Non-certified	31.627	0.000 **	11.620	0.001 **
ISRS-certified Vs Non-certified	79.479	0.000 **	17.778	0.000 **
ISO-certified Vs Non-certified	2.968	0.085 ns	0.051	0.821 ns
OHSAS-certified Vs ISRS-certified	3.728	0.054 ns	0.013	0.908 ns
OHSAS-certified Vs ISO-certified	20.642	0.000 **	11.191	0.001 **
ISRS-certified Vs ISO-certified	58.504	0.000 **	16.952	0.000 **

** indicates $p < 0.01$, ns – non-significant

The difference between non-certified firms and ISRS certified firm is significant ($p < 0.01$) with respect to both COM and PAR. Hence the null hypothesis $H_{0.3}$ was rejected. This indicates that the level of Safety Compliance and Safety Participation of employees is higher in ISRS certified firm than in non-certified firms.

The difference between non-certified firms and ISO certified firms is not significant with respect to both COM and PAR. Hence the null hypothesis $H_{0.4}$ was supported. This indicate that the levels of Safety Compliance and Safety Participation of employees are similar in ISO certified firms and non-certified firms.

The difference between ISRS certified firm and OHSAS certified firm is not significant with respect to both COM and PAR. Hence the null hypothesis $H_{0.5}$ was supported. This indicates that the levels of Safety Compliance and Safety Participation of employees are similar in OHSAS certified firm and ISRS certified firm.

The difference between ISO certified firms and OHSAS certified firm is significant ($p < 0.01$) with respect to both COM and PAR. Hence the null hypothesis $H_{0.6}$ was rejected. This indicates that the level of Safety Compliance and Safety Participation of employees is higher in OHSAS certified firm than in ISO certified firms.

The difference between ISRS certified firm and ISO certified firms is significant ($p < 0.01$) with respect to both COM and PAR. Hence the null hypothesis $H_{0.7}$ is rejected. This indicates that the level of Safety Compliance and Safety Participation of employees is higher in ISRS certified firm than in ISO certified firms.

From the above findings, it is concluded that employees in system certified firms have better Safety Compliance and Safety Participation compared with non-certified firms. However, in ISO certified firms, the efforts are not sufficient enough compared with OHSAS certified and ISRS certified firms and the safety behaviour of employees remains at par with non-certified firms.

It is reported that, even though safety means quality (Carder and Ragan, 2003), and the regulations based on ISO 9000 have been created to guide companies in developing systems for management and the prevention of worker risks (Herrero et al., 2002), it warrants extra commitment from the management to channel its efforts for safe guarding their employees. Managements tend to neglect this, as the cost – benefit aspect do not appear very attractive in short-term vision. OHSAS certified and ISRS certified firms are found to have similar levels of Safety Compliance and Safety Participation among the employees. To be more specific, it can be concluded that OHSAS certified and ISRS certified firms are better than ISO certified and non-certified firms, with respect to the components of safety performance, COM and PAR.

5.5.6 Impact of accidents on components of safety performance

The effects of accident rate on components of safety performance were studied using one-way ANOVA test. Initially the responses were tested to find out whether there was any significant difference among the groups using ANOVA with all groups taken together. The null hypothesis to be tested was:

H_0: There is no significant difference between groups with respect to components of safety performance.

The results of ANOVA test are presented in Table 5.31. It is evident from "F" and "p" values that there is significant difference between the groups and hence the null hypothesis was rejected and the alternate hypothesis stating that the groups differ significantly with respect to determinants of safety performance was accepted. Figure 5.10 shows the mean scores of COM and PAR for the 3 accident groups for a comparative study. Therefore, for further investigation, following three null hypotheses were advanced and tested using one-way ANOVA with two groups taken at a time.

Table 5.31 Difference in the levels of components of safety performance with respect to accidents. Results of ANOVA: (all groups taken together)

Compo-	Low		Medium		High		F	p
nents	Mean	SD	Mean	SD	Mean	SD	value	value
COM	4.157	0.563	3.813	0.703	3.741	0.731	48.987	0.000**
PAR	3.937	0.535	3.772	0.616	3.719	0.652	15.702	0.000**

** indicate $p < 0.01$

H_{01}: There is no significant difference between low and medium accident groups with respect to components of safety performance.

H_{02}: There is no significant difference between medium and high accident groups with respect to components of safety performance.

H_{03}: There is no significant difference between high and low accident groups with respect to components of safety performance.

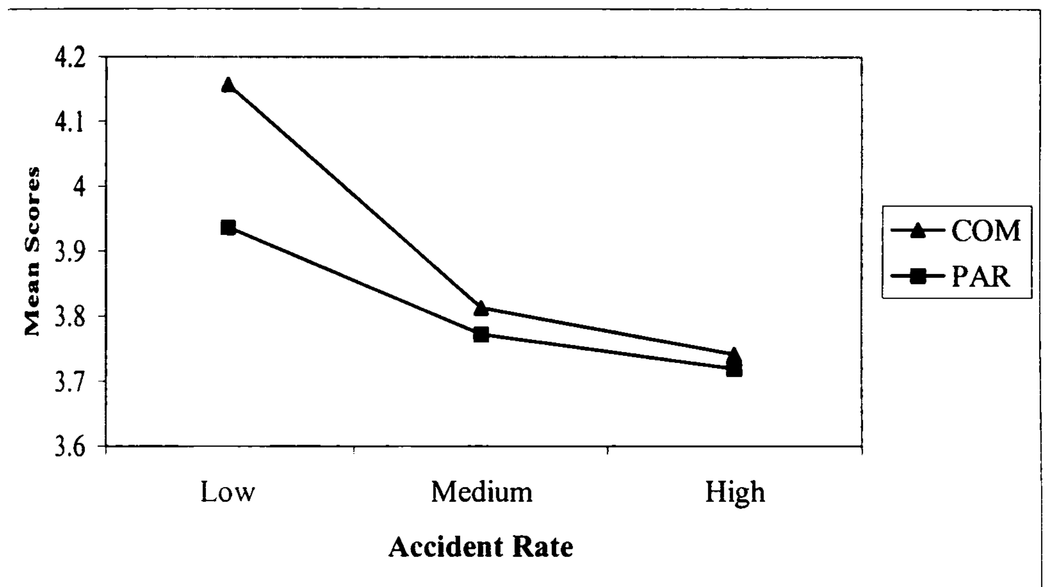

Figure 5.10 Accident Rate Vs Components of Safety performance

These three hypotheses were tested separately for each of the dependent variables (COM and PAR) and the results are presented in Table 5.32. The following observations are made from the above results:

Table 5.32 Impact of accidents on Safety Compliance (COM) and Safety Participation (PAR). Comparison of components of safety performance between groups- ANOVA results: (taken two at a time)

Groups	Safety Compliance (COM)		Safety Participation (PAR)	
	F - value	p - value	F - value	p - value
Low Vs Medium	78.725	0.000 **	22.525	0.000 **
Medium Vs High	3.068	0.080 ns	2.197	0.139 ns
High Vs Low	87.735	0.000 **	28.925	0.000 **

** indicates $p < 0.01$, ns – non-significant

The levels of COM and PAR are significantly lower in medium accident rate organizations compared with low accident rate organizations. Hence, null hypothesis (H_{01}) was rejected. Medium and high accident rate organizations have same levels of

COM and PAR and hence hypothesis ($H_{0.2}$) was accepted. High and low accident rate organizations differ significantly with respect to both COM and PAR, rejecting hypothesis ($H_{0.3}$).

Lower levels of Safety Compliance and Safety Participation among their employees characterize organizations with higher rates of self-reported accidents.

5.6 MODELLING SAFETY PERFORMANCE

Multiple Linear Regression analysis (Section 5.3.3.1) revealed that safety management practices predicted only 23 % (coefficient of determination R^2=0.23) of variation in Safety Knowledge and only 8 % (coefficient of determination R^2=0.08) of variation in Safety Motivation. Similarly, Multiple Linear Regression analysis (Section 5.5.3.1) revealed that determinants of safety performance (KNO and MOT) predicted 44 % (coefficient of determination R^2=0.44) of variation in Safety Compliance and only 33 % (coefficient of determination R^2=0.33) of variation in Safety Participation. Even though all these four models and the regression coefficients were found to be statistically significant, the linear relationships between the dependent and independent variables were found to be weak. The R^2 values were not sufficiently high to establish conclusively that the independent variables predicted the dependent variables.

Therefore, Structural Equation Modelling was used to study the relationships between the antecedents of safety performance, determinants of safety performance and components of safety performance.

5.6.1 Structural Equation Modelling

Structural Equation Modelling (SEM) is a multivariate statistical methodology, which takes a confirmatory approach to the analysis of a structural theory. SEM provides researchers with the ability to accommodate multiple interrelated dependence relationships in a single model. Its closest analogy is multiple regression analysis, which can estimate a single relationship. But SEM can estimate many equations at once, and they can be interrelated, meaning that the dependent variable in one equation can be an independent variable in other equations. This allows the researcher to model complex relationships that are not possible with other multivariate techniques (Hair et al., 1998).

SEM technique attempts to identify 'causal' processes. These processes are represented by a series of structural equations, which can also be modeled pictorially. A hypothesized model can be tested statistically in a simultaneous analysis of all the variables, to determine the extent to which it is consistent with the observed data. The strength of the relationship between variables is given by the path coefficients.

The proposed model for the data in this study is shown in Figure 5.11. It was argued that the six safety management practices (antecedents of safety performance) should predict the determinants of safety performance, which should predict the components of safety performance. The overall fit of this model was assessed using a number of fit indices. Statistical package AMOS 4 was used for this analysis. There is broad consensus that no single measure of overall fit should be relied on exclusively and a variety of different indices should be consulted (Tanaka, 1993). The indices used here included Chi-square (χ^2), Goodness of Fit Index (GFI; Joreskog and Sorbom, 1989), Non-normed Fit Index (NNFI (TLI); Bentler and Bonett, 1980), Comparative Fit Index (CFI; Bentler, 1990) and Root Mean Squared Residual (RMSR).

The chi-square is used as a measure of the proposed model to the actual covariance data. Ideally, chi-square should be small and non-significant, the fit indices GFI, TLI and CFI between 0.90 and 1.00 and the RMSR should be close to 0 for a good fit. The RMSR is a measure of the average variance unaccounted for by the model and the usually accepted threshold value is ≤ 0.05 (Hansen, 1989).

5.6.2 Hypothesized model

First the hypothesized model depicted in Figure 5.11 was estimated. The results are presented in Table 33. Even though the fit indices were found to be good (closer to 1), some of the standardized path coefficients were found to be non-significant. MC and SP were found to have no relationship with the determinants of safety performance. Therefore, four alternate models were proposed and tested.

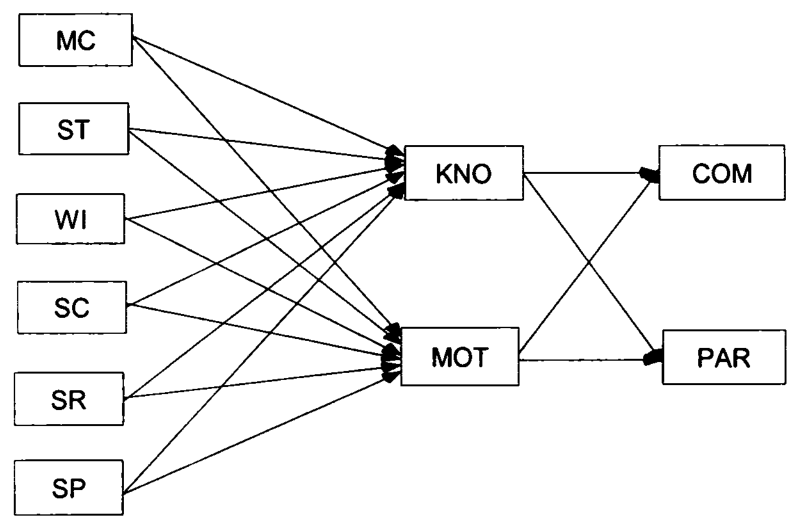

Figure 5.11 Hypothesized Model

5.6.3 Alternate models

After removing the non-significant paths in the hypothesized model (MC-KNO, MC-MOT, WI-KNO, SC-MOT, SR-MOT, SP-KNO and SP-MOT), MC was connected to PAR and SP was connected to COM to produce Model 1. This was done assuming that the demonstration of management commitment to safety will increase the employees' participation in safety and safety promotion policies will increase the safety compliance of workers. On estimation of the model, the fit indices were found good and the path coefficients also were found significant. The estimated values are presented in Table 33. It is found that chi-square and RMSR values have come down and GFI, TLI and CFI values have improved showing a better fit. Since the chi-square value was still high and significant, alternate model 2 was proposed.

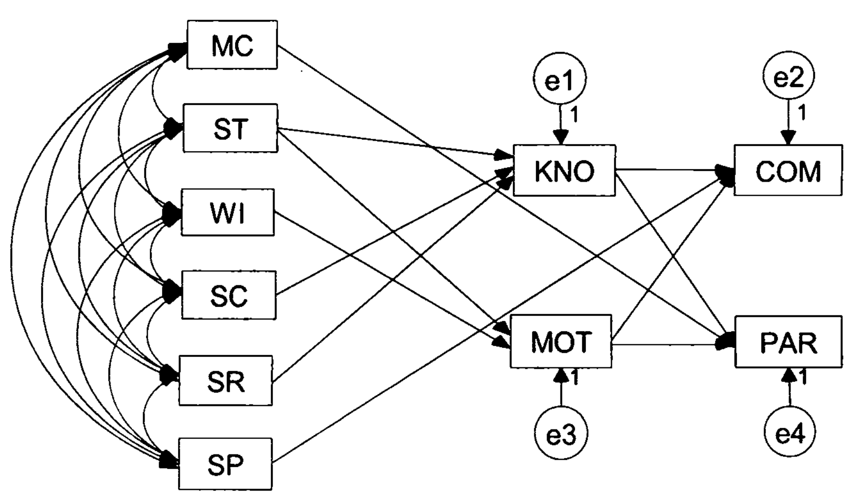

Figure 5.12 Alternate Model 1

Alternate Model 2 was formed by interchanging the direct paths between MC-PAR and SP-COM in Model 1 (Figure 5.13). On estimation of the model, the fit indices were found good and the path coefficients also were found significant. The estimated fit indices given in Table 33 reveal that chi-square and RMSR values have decreased further and GFI, TLI and CFI values have improved indicating a better fit for the data.

As the chi-square value was still significant, a third model was prepared connecting MC and SP to both COM and PAR (Figure 14). Even though the chi-square value dropped further considerably, it was still found significant (p=0.001). RMSR became closer to 0 and the fit indices improved further and became closer to 1. All the path coefficients were also found significant in this model.

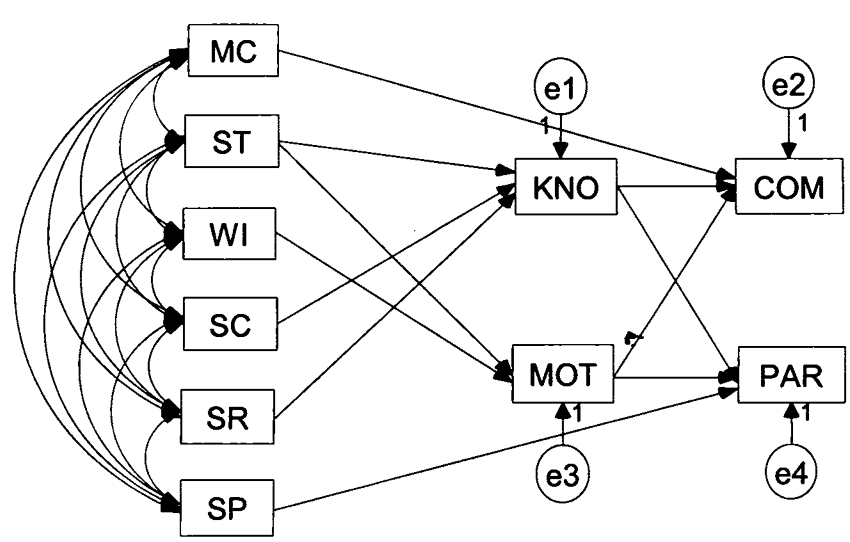

Figure 5.13 Alternate Model 2

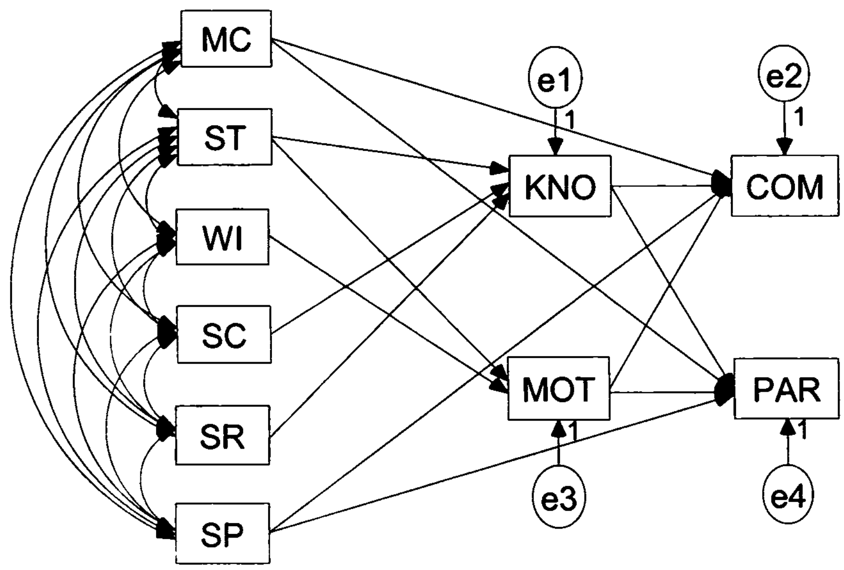

Figure 5.14 Alternate Model 3

Finally a fourth model was prepared as shown in Figure 5.15. The estimated values are given in Table 33. It is found that chi-square value has become non-significant (23.216, p=0.08) indicating that the model fits the data and the RMSR value has become very close to 0. The fit indices GFI = 0.997, TLI =0.998 and CFI =0.999 indicate a very good fit for the data. The standardized path coefficients are also shown in Figure 5.15.

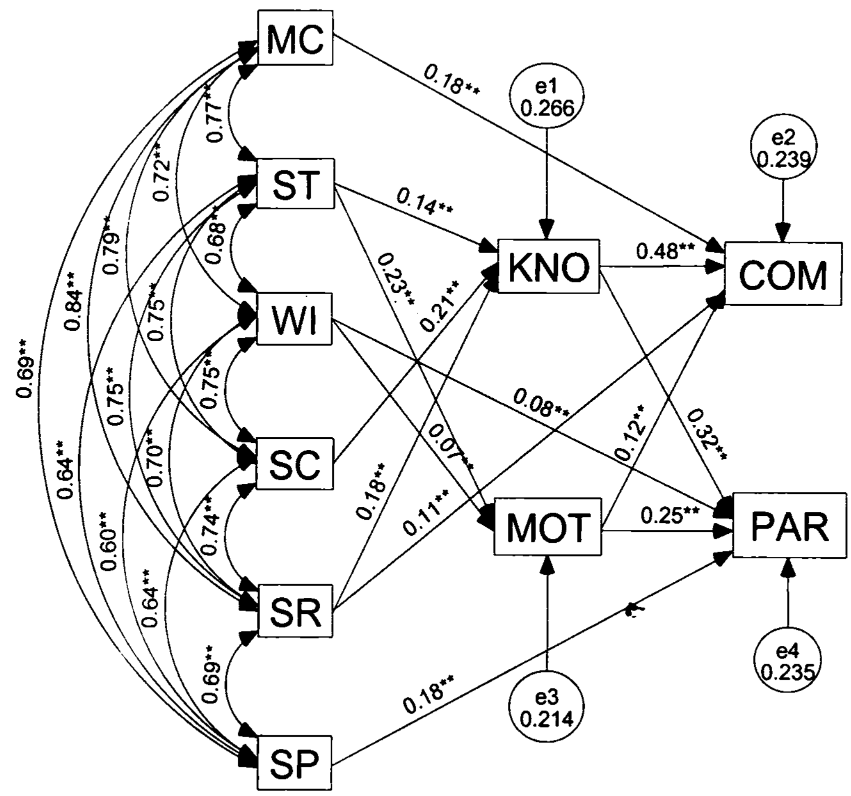

Figure 5.15 Final Model

Table 5.33 Comparison of Models Fit indices

Model	χ^2	d.f.	p	χ^2/d.f.	RMSR	GFI	TLI	CFI
Hypothesized Model	315.334	12	0.000	26.278	0.046	0.968	0.908	0.946
Alternate Model 1	231.104	17	0.000	13.594	0.025	0.976	0.954	0.983
Alternate Model 2	49.405	17	0.000	2.906	0.009	0.995	0.993	0.977
Alternate Model 3	37.354	15	0.001	2.490	0.004	0.996	0.995	0.998
Final Model	23.216	15	0.080	1.548	0.004	0.997	0.998	0.999

The following conclusions are reached from the final model presented in Figure 5.15.

- Out of the six safety management practices, ST, SC and SR are significant predictors of Safety Knowledge and ST and WI are significant predictors of Safety Motivation.
- Safety Knowledge and Safety Motivation predict both Safety Compliance and Safety Participation. This finding is in agreement with Neal et al. (2000).
- The relationship between Safety Knowledge and Safety Compliance is stronger than the relationship between Safety Knowledge and Safety Participation. This testified the findings of Neal et al. (2000).
- The relationship between Safety Motivation and Safety Participation is stronger than the relationship between Safety Motivation and Safety Compliance. Neal et al. (2000) hypothesized this relationship but his data did not support this hypothesis.
- MC and SR have significant direct effects on Safety Compliance.
- SP and WI have significant direct effects on Safety Participation.
- The determinants of safety performance (KNO and MOT) partially mediate the relationship between the antecedents of safety performance (Safety Management Practices) and components of safety performance (COM and PAR). This is due to the direct paths from MC and SR to COM and SP and WI to PAR. This finding is in tune with Neal et al. (2000).

5.7 SUMMARY

The study reported in this chapter attempted to identify and validate the determinants and components of safety performance with the help of the questionnaire used in Chapter 3. The relationship between the safety management practices (identified and validated in Chapter 3) and determinants of safety performance was investigated to examine the predictive capacity. Similarly, the relationship between determinants and components of safety performance was also explored to find the predictive capacity of the former on the latter. The impact of system certification on the determinants and components of safety performance was examined along with the impact of system certification on the relationship between safety management practices, determinants and components of safety performance.

An investigation was done to find out the difference in levels of determinants and components of safety performance in companies grouped on the basis of accident rates. This research also tried to explore the relationship of personal variables such as qualification, age, tenure, job category and accident history on determinants and components of safety performance.

Finally a safety performance model was proposed relating the safety management practices, determinants and components of safety performance.

The results of this study can be summarized as follows.

- Safety Knowledge (KNO) and Safety Motivation (MOT) were identified and validated as determinants of safety performance.
- ST, SC and SR were found to be significant predictors capable of explaining 23 % of the variance in KNO.
- ST and WI were found to predict MOT, but the variance explained was only 8 %.
- MOT increases significantly with qualification and KNO is significantly high for people with high qualification.
- KNO decreases with increase in age significantly and then increases, as they grow older. MOT decreases with increase in age first and then remain almost at the same level.

Impact of tenure in the company on KNO and MOT is identical to that of age.

Supervisors have better KNO and higher MOT compared with workers.

Employees who never met with accidents in workplace possess higher level of KNO than others, while both groups have same level of MOT.

Organizations were classified as OHSAS certified, ISRS certified, ISO certified and non-certified firms and ANOVA tests revealed that the levels of both KNO and MOT are not significantly different in ISO and non-certified firms and also in OHSAS and ISRS certified firms. For all other pairs, both KNO and MOT were found to be significantly different.

Both KNO and MOT are significantly high in low accident rate organizations compared to medium and high accident rate organizations.

Safety Compliance (COM) and Safety Participation (PAR) were identified and validated as components of safety performance.

KNO and MOT together explained 44% of variance in COM.

KNO and MOT together explained 33% of variance in PAR.

Employees with higher qualifications comply with safety rules better than others while qualification has no impact on participatory activities of employees.

Middle-aged employees show significantly lower safety compliance compared to low and high age groups. Interestingly, age has no relationship with participatory activities.

Tenure and age have similar impact on components of safety performance.

Supervisors and workers have similar levels of COM and PAR.

People who met with accidents while working exhibit significantly lower levels of COM and PAR.

Comparing the components of safety performance in organizations categorized based on system certification, it was found that the levels of both COM and PAR are not significantly different in ISO and non-certified firms and also in OHSAS and ISRS certified firms. For all other pairs, both COM and PAR were found to be significantly different.

- Both COM and PAR are significantly high in low accident rate organizations compared to medium and high accident rate organizations.
- A model for safety performance connecting the antecedents, determinants and components of safety performance was proposed and tested statistically to examine whether the data collected through the survey fit the model well. The final accepted model revealed that the determinants of safety performance partially mediated the relationship between antecedents and components of safety performance.

This work adds to the literature on safety performance, especially in a developing country like India.

CHAPTER 6

DETERMINATION OF UNDERLYING FACTORS IN SAFETY CLIMATE AND THEIR RELATIONSHIP WITH ACCIDENTS AND MANAGEMENT SYSTEM CERTIFICATION

Section 6.1 explains the concept of safety climate in industries. Section 6.2 contains the details about the measuring instrument, data collection, analysis, results and discussion. The reliability of the safety climate scale developed is examined in Section 6.3 and Section 6.4 gives the validation attempt using CFA. Section 6.5 presents a comparative study on the level of safety climate factors across organizations. Predictive validity of safety climate factors is presented in Section 6.6. Section 6.7 compares safety climate in organizations grouped on the basis of accident rate. Relationship between safety climate factors and management system certification in industries is presented in Section 6.8. Section 6.9 contains the summary of this chapter.

6.1 SAFETY CLIMATE

Safety climate is regarded as a manifestation of safety culture in the behaviour and expressed attitude of employees (Cox and Flin, 1998), and is a more tangible expression of the safety culture in the form of symbolic and political aspects of the organization (Kennedy and Kirwan, 1998). Safety climate is best considered a subset of organizational climate. Safety climate factors will characterize and influence the deployment and effectiveness of the safety management resources, policies, practices and procedures. It has been suggested that safety climate surveys are a much better predictor of an organizational safety performance as it overcomes many of the limitations of traditional safety measures such as reporting biases and after-the-fact measurement. Ojanen et al. (1988) suggested that safety performance should be measured on multiple levels, one of them being safety attitudes, in order to determine the real safety level of an organization. They claimed that measuring safety climate can indicate changes in organizational safety behaviour and would therefore be useful for evaluating safety programmes and suggested that safety climate questionnaire is the only way to measure safety climate in an organization.

6.2 INSTRUMENT, DATA COLLECTION, RESULTS AND DISCUSSION

6.2.1 Survey instrument and data collection

The same questionnaire and responses collected from the workers described in Chapter 3 and 5 used to measure employees' perception of the six safety management practices, two determinants of safety performance and two components of safety performance along with four additional questions related to safety of work environment were used in this study. The initial questionnaire consisted of 82 questions. This was reduced to 62 after pilot study and discussion with safety experts from industries and academics. Table 6.1 gives the various organizational dimensions and the number of items in each dimension.

Table 6.1 Organizational dimensions and number of items

No.	Dimensions	No. of items
1	Management commitment	9
2	Safety training	6
3	Worker involvement in safety	5
4	Safety Communication and feedback	5
5	Safety rules and procedures	5
6	Safety promotion policies	4
7	Safety of work environment	4
8	Safety knowledge	6
9	Safety motivation	6
10	Safety compliance	7
11	Safety participation	5
	Total	62

6.2.2 Factor analysis

Factor analysis is a multivariate statistical method whose primary purpose is to define the underlying structure in a data matrix. It addresses the problem of analyzing the structure of the relationships (correlations) among a large number of variables by defining a set of common underlying dimensions known as factors. With factor analysis, the researcher can first identify the separate dimensions of the structure and then determine the extent to which each variable is explained by each dimension (Gorsuch, 1974; Rummel, 1970).

In this study, the same questionnaire and responses that was used to measure the identified safety management practices and determinants and components of safety performance, along with few questions to measure the safety of work environment were factor analyzed to investigate whether the same or similar structure is obtained in the factor analysis. The argument of Zohar (1980) that safety climate appears to be directly related to the safety record of an organization can be accepted if a set of factors representing the various management practices and determinants and components of safety performance are obtained in the analysis. When Glennon (1982) almost agreed with Zohar (1980) as he obtained closer set of factors, many researchers (e.g., Brown and Holmes, 1986; Coyle et al., 1995) challenged the findings of Zohar (1980).

Out of 1806 completed responses received from 8 chemical industrial units surveyed, approximately 75% was selected randomly for factor analysis for determining the structure of safety climate. This was subjected to principal component factor analysis using SPSS 10 statistical package. The data was deemed appropriate for analysis as the case-to-variable ratio was above 10:1 (Tabachnick and Fidell, 1996; Gorsuch, 1974; Hair et al., 1998). A varimax rotation was performed to enhance factor interpretability. Those items, which failed to attain minimum correlations of 0.3 with any other item, were removed initially. The factor loading cut-off was fixed at 0.4 as recommended by Hair et al. (1998). The step-by-step analysis resulted in removal of 8 items from the total of 62 items. This procedure finally resulted in 8 factors with eigen values greater than one which explained 52.147 % of the total variance. Kaiser-Meyer-Oaklin measure of sampling adequacy (KMO value) obtained was 0.961, which was above the meritorious value of 0.8 (Hair et al., 1998). Bartlett Test of Sphericity was significant (χ^2 = 32255, degrees of freedom = 1540, $p < 0.001$), indicating that correlations exist among some of the response categories.

There were totally 54 items in the scale. The eight factors with their names, number of items in each factor, factor loadings and variance explained are presented in Table 6.2. The factors and sample questions are presented in Table 6.3.

Table 6.2 Results of factor analysis showing factor names, no. of items, factor loadings, % variance explained and Cronbach alpha values

No	Factor name	No of items	Factor loading	% Variance explained	Cronbach Alpha (α)
1	Management attitude and actions for safety	25	0.755-0.464	28.43 %	0.9522
2	Workers' knowledge and compliance to safety	7	0.677-0.454	6.675 %	0.8039
3	Workers' attitude towards safety	5	7.729-0.479	4.078	0.7352
4	Workers' participation and commitment to safety	5	0.629-0.434	3.522	0.7444
5	Safeness of work environment	3	0.766-0.664	2.753	0.6316
6	Emergency preparedness in the organization	4	0.659-0.451	2.440	0.6116
7	Priority for safety over production	3	0.630-0.566	2.192	0.5349
8	Risk justification	2	0.852-0.817	2.057	0.6481

The results show that all the safety management practices failed to produce separate factors but formed a single factor comprising of 25 items explaining 28.43 % of the total variance. This is in tune with Brown and Holmes (1986). Even though a similar factor structure was not reported in a single study, all these eight factors are found separately in a number of previous researches (e.g., Zohar, 1980; Glennon, 1982a,b; Brown and

Holmes, 1986; Cox and Cox, 1991; Dedobbeleer and Beland, 1991; Ostrom et al.,1993; Phillips et al., 1993; Cooper and Phillips, 1994; Niskanen, 1994; Geller, 1994; Alexander et al., 1995; Coyle et al., 1995; Janssens et al., 1995; Berends, 1996; Lee, 1996; Budworth, 1997; Mearns et al., 1997; Cabrera et al., 1997; Diaz and Cabrera, 1997; Williamson et al., 1997; Carroll, 1998; Varonen and Mattila, 2000; O'Toole, 2002).

Table 6.3 Factor names and sample questions from each factor

No	Factor names and sample questions
1	Management attitude and actions for safety Eg. 1. Safety is given high priority by the management. 2. Safety issues are given high priority in training programmes. 3. Management promotes employees' involvement in safety related matters. 4. Management operates an open door policy on safety issues. 5. The safety procedures and practices in this organizations are useful and effective.
2	Workers' knowledge and compliance to safety Eg. I know how to perform my job in a safe manner.
3	Workers' attitude towards safety Eg. I feel that it is important to maintain safety at all times.
4	Workers' participation and commitment to safety Eg I encourage my co-workers to work safely.
5	Safeness of work environment Eg. In my workplace, the chances of being involved in an accident are quite high
6	Emergency preparedness in the organization Eg. I am not adequately trained to respond to emergency situations in my workplace.
7	Priority for safety over production Eg. I believe that safety can be compromised for increasing production.
8	Risk justification Eg. Occasionally due to over familiarity with the job, I deviate from correct and safe work procedures.

Hale (2000) noted that few safety climate scales have been reused between studies and that where this has occurred, factor structures and results have not usually been replicated. One explanation for inconsistencies in factor structures is the variety of questionnaires, samples and methodology used by different researchers. However, even when the same questionnaire is used, as in research by Zohar (1980), Brown and Holmes (1986) and Coyle et al. (1995), different factor structures have still been found. Alternatively, Coyle et al. (1995) suggested that no universal set of safety climate factors exists. McDonald and Ryan (1992) maintained that the factors that influence safety climate within one industry may not be valid for another. The argument is that because organizations differ in management style and safety regulations, different safety perceptions result, which are then reflected in different factor structures.

Based on the above arguments, the eight-factor safety climate structure obtained in this study is accepted, provided, the reliability and validity are found good.

6.3 RELIABILITY

Hair et al. (1998) argues that any scale developed should be analyzed for item-specific and overall reliability to ensure its appropriateness before proceeding to an assessment of its validity. Reliability of an instrument is defined as the extent to which any measuring instrument yields the same result on repeated trials (Carmines and Zeller, 1990). Out of many methods, internal consistency method is considered to be the most effective method especially in field studies. The internal-scale reliability (Cronbach Alpha) of the scale was estimated as 0.9453, which is above the acceptable limit of 0.6 for exploratory research (Hair et al., 1998; Gregory, 1996). The reliability coefficients across items in each factor were found to be above 0.6 except for factor 7, 'Priority for safety over production' (Table 6.2). However, it was decided to keep factor 7 and explore its characteristics further in the validation phase of the development of the scale. As an alternate step, the split half reliability coefficients for the safety climate scale were computed for the 54 items. The results found reliability coefficients of 0.9051 for part one comprising of 27 items and 0.8880 for part two comprising of 27 items. Over all, the safety climate scale developed has high degree of reliability.

6.4 CONFIRMATORY FACTOR ANALYSIS

In Confirmatory Factor Analysis the researcher postulates a model (a particular set of linkages between the observed variables and their underlying factors) and then tests this model statistically, examining the degree to which it fits with the available data. In its confirmatory approach, factor analysis is concerned with implementing a theorist's hypothesis about how a domain of variables may be structured.

Following the procedure already used by other authors (Brown and Holmes, 1986; Dedobbeleer and Beland, 1991; Neal et al., 2000; Cox and Cheyne, 2000; Silva et al., 2004) the final version of the safety climate scale consisting of 8 factors was subjected to confirmatory factor analysis using the 25% data that was kept aside for the purpose. AMOS 4 structural equations modelling program was used for this analysis. The main goal of this analysis was to test if the safety climate factor structure obtained in exploratory factor analysis was reflected in this data. Results, considering some of the more consensual goodness fit statistics such as Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) (Byrne, 2001; Kline, 1998), revealed that the model fitted well the data (Table 6.4). Both CFI and TLI were more than 0.9 indicating good model fit. The chi-square value was significant (it need to be non-significant for a good fit) and hence less acceptable due to the large sample size. In fact, many authors stress that for large samples the chi- square is always significant (Byrne, 2001; Kline, 1998).

Table 6.4 Results of CFA of safety climate model - Fit indices

Data	χ^2	DF	χ^2/ DF	p	CFI	TLI
25 % data	3050.866	1351	2.26	0.000	0.974	0.971
75 % data	5842.832	1351	4.32	0.000	0.980	0.978
100% data	7201.105	1351	5.33	0.000	0.980	0.978

The above analyses testify the reliability and validity of the safety climate factor structure and hence it is accepted.

6.5 LEVEL OF SAFETY CLIMATE FACTORS ACROSS ORGANIZATIONS

To explore the level of safety climate factors in organizations under study, the means of the summated safety climate scores of each of the eight factors and self-reported accident rates of each of the eight companies were calculated. These are presented in Table 6.5.

Table 6.5 Means of safety climate factor scores and accidents

Org	F 1	F 2	F 3	F 4	F 5	F 6	F 7	F 8	F sum	Acc. Rate
1	86.366	27.531	22.085	18.772	7.692	14.817	9.929	6.058	193.250	0.067
2	82.592	26.705	22.091	18.536	7.330	13.525	9.525	6.440	186.745	0.091
3	84.461	26.712	22.152	18.490	7.222	14.152	9.634	6.107	188.930	0.099
4	78.125	27.018	21.917	18.619	8.185	13.214	9.446	6.369	182.893	0.060
5	72.368	26.691	22.299	18.142	8.029	12.882	9.230	6.569	176.211	0.142
6	73.830	27.117	21.982	18.573	7.988	13.561	9.807	6.064	178.924	0.064
7	99.601	28.869	22.720	19.554	8.786	15.815	10.780	6.065	212.190	0.030
8	94.569	29.043	22.929	19.804	7.851	15.812	11.447	6.710	208.165	0.031

6.5.1 Hypothesis to be tested

From Table 6.5, it is seen that the mean scores of all eight safety climate factors and total safety climate scores varies from organization to organization. Thus, there is an apparent difference in the levels of these factors across organizations. To analyze whether this difference is significant or not, the following hypothesis was formulated.

H_0 : There is no significant difference between organizations with respect to the level of eight safety climate factors.

To test the null hypothesis (H_0), one-way ANOVA F-test was used.

6.5.2 Results and discussion

The results of this ANOVA test are presented in Table 6.6. The ANOVA results indicate that the difference in levels of all the eight safety climate factors and total safety climate score across organizations are significant. Here, the alternate hypothesis proposing a difference in the levels of safety climate factors across organizations was accepted beyond 0.01 level of significance.

Table 6.6 One- way ANOVA. Safety climate factor scores across organizations.

	Factor Name	F value	p value
F 1	Management attitude and actions for safety	57.277	0.000**
F 2	Workers' knowledge and compliance to safety	13.448	0.000**
F 3	Workers' attitudes towards safety	5.048	0.000**
F 4	Workers' participation and commitment to safety	7.546	0.000**
F 5	Safeness of work environment	7.297	0.000**
F 6	Emergency preparedness in the organization	35.576	0.000**
F 7	Priority for safety over production	22.187	0.000**
F 8	Risk justification	3.798	0.000**
	Total safety climate score	50.059	0.000**

** indicate $p < 0.01$

This result is in tune with Zohar (1980) who found that organizations have different safety climate levels in the study conducted in a variety of industries in Israel.

6.6 PREDICTIVE VALIDITY

Predictive validity of the instrument was examined through correlations among safety climate factors and accident data. Given two sites with relatively equal hazard risks, the one with the better safety climate score should have fewer accidents. To proceed with this analysis, the data presented in Table 6.5 was used.

6.6.1 Hypotheses to be tested

To examine the validity, the following hypotheses were formulated:

$H_{1.1}$: There is significant negative correlation between "Management attitude and actions for safety" and the accident rate.

$H_{1.2}$: There is significant negative correlation between "Workers' knowledge and compliance to safety" and the accident rate.

$H_{1.3}$: There is significant negative correlation between "Workers' attitude towards safety" and the accident rate.

$H_{1.4}$: There is significant negative correlation between "Workers' participation and commitment to safety" and the accident rate.

$H_{1.5}$: There is significant negative correlation between "Safeness of work environment" and the accident rate.

$H_{1.6}$: There is significant negative correlation between "Emergency preparedness in the organization" and the accident rate.

$H_{1.7}$: There is significant negative correlation between "Priority for safety over production" and the accident rate.

$H_{1.8}$: There is significant negative correlation between "Risk justification" and the accident rate.

$H_{1.9}$: There is significant negative correlation between "Total safety climate score" and the accident rate.

To test these hypotheses, Pearson's correlation coefficients were calculated.

6.6.2 Results and discussion

Table 6.7 reveals that safety climate factor scores are negatively correlated with accident rates indicating that, as safety climate factor scores increase, accidents decrease. Five correlations were found significant supporting hypotheses $H_{1.1}$, $H_{1.2}$, $H_{1.4}$, $H_{1.6}$ and $H_{1.7}$. Hypothesis $H_{1.3}$ is related to the attitude of workers towards safety (F3) and this was not supported by the data. This indicates that significant difference between organizations with respect to F3 is not related to accidents but due to some other reasons. Hypothesis $H_{1.5}$ relating safeness of work environment (F5) to accidents is also not supported and this means that the significant difference between organizations with respect to F5 is not related to accidents but due to some other reasons.

Hypothesis $H_{1.8}$ proposing a significant negative correlation between factor 'Risk justification (F8)' and accident rate also failed to get support. Even though organizations differ significantly with respect to F8, the lack of correlation between F8 and accident rate proposes other unknown influence on the former relationship. Investigation in-to this behaviour revealed that people at the high end of age group took lesser risks in their work, but met with more accidents due to other reasons. Correlation between total safety climate score and accident rate was found to be significant and in the desired direction supporting hypothesis $H_{1.9}$. A scatter plot showing the variation of accident rate with safety climate score is presented in Figure 6.1.

Table 6.7 Pearson's correlation coefficients showing relationship between safety climate factor scores and self-reported accident rates

Factors	Factor Name	Pearson's Correlation coefficients	p value
1	Management attitude and actions for safety	-0.716	0.046*
2	Workers' knowledge and compliance to safety	-0.814	0.014*
3	Workers' attitudes towards safety	-0.453	ns
4	Workers' participation and commitment to safety	-0.867	0.005**
5	Safeness of work environment	-0.453	ns
6	Emergency preparedness in the organization	-0.761	0.028*
7	Priority for safety over production	-0.793	0.019*
8	Risk justification	-0.175	ns
	Total safety climate score	-0.757	0.030*

* indicate $p < 0.05$ ** indicate $p < 0.01$ ns - indicate non-significant

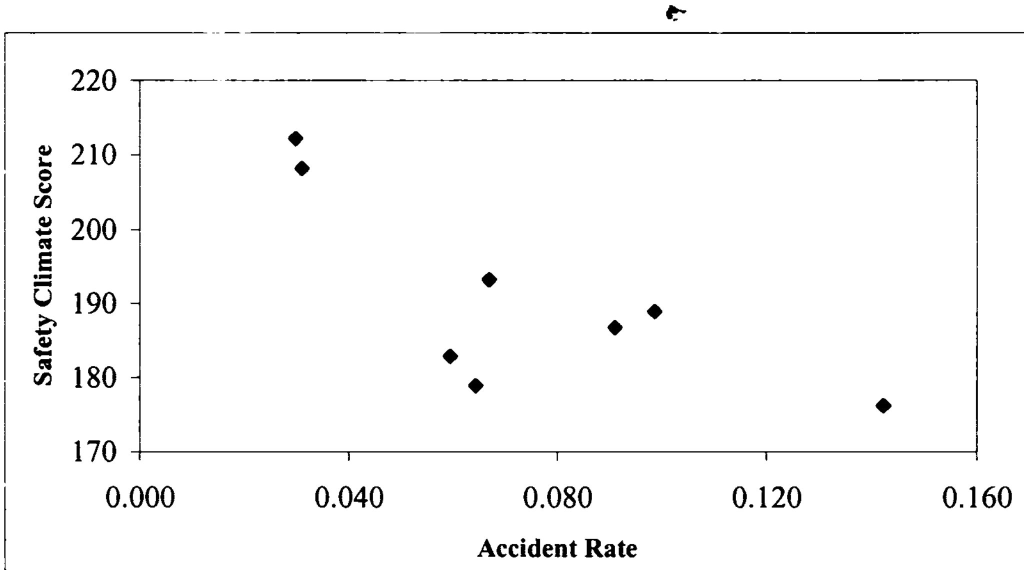

Figure 6.1 Scatter plot. Safety Climate Score Vs Accident Rate

6.7 COMPARISON OF ORGANIZATIONS BASED ON ACCIDENT DATA

6.7.1 Hypothesis to be tested

Once it was established that organizations have different levels of safety climate in them, and safety climate factors are capable of predicting accident rates, it was worth investigating the characteristics of organizations grouped on the basis of accident rates. For this purpose, organizations were classified into 3 groups based on the self-reported accident rate, namely low accident rate, medium accident rate and high accident rate organizations. The safety climate factor scores for the above three categories of firms are given in figure 6.2.

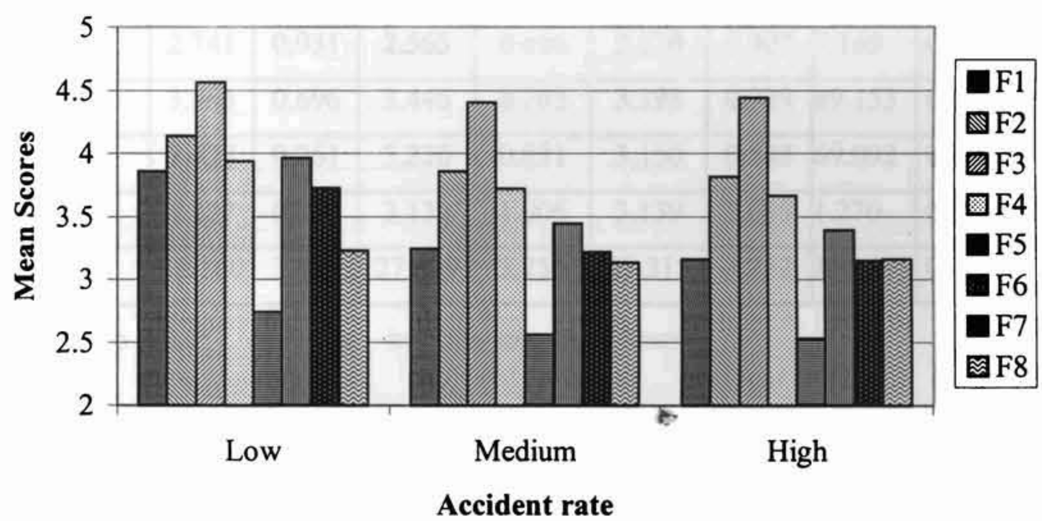

Figure 6.2 Accident Rate Vs Mean Scores of Safety Climate Factors

To test whether there is any difference among the groups (based on accident rate), the following hypothesis was formulated.

$H_{0.1}$: There is no significant difference between the groups with respect to each safety climate factor.

To test the null hypothesis ($H_{0.1}$), one-way ANOVA F-test, considering all groups together, was used. The result of this ANOVA test is presented in Table 6.8. The results show that there is significant difference between the groups with respect to all safety climate factors except F8. The total safety management score also differ significantly between the groups. The F statistics for all factors except F8 show significance level beyond 0.01. Therefore, the null hypothesis $H_{0.1}$ was partially supported, indicating that there is difference between the groups with respect to most of the safety climate factors.

Table 6.8 Difference in the levels of Safety climate factors with respect to Accidents
Results of ANOVA : (all groups taken together)

Safety Climate Factors	Low acc. rate		Medium acc. rate		High acc. rate		F value	p value
	Mean	SD	Mean	SD	Mean	SD		
F1	3.863	0.570	3.244	0.770	3.158	0.742	132.570	0.000**
F2	4.139	0.461	3.862	0.584	3.815	0.627	43.876	0.000**
F3	4.569	0.411	4.408	0.489	4.444	0.517	16.708	0.000**
F4	3.941	0.539	3.723	0.626	3.666	0.667	24.979	0.000**
F5	2.741	0.931	2.563	0.896	2.530	0.907	7.169	0.001**
F6	3.963	0.696	3.446	0.702	3.393	0.739	89.153	0.000**
F7	3.727	0.761	3.220	0.831	3.150	0.843	69.092	0.000**
F8	3.227	0.987	3.134	1.006	3.159	1.005	1.270	0.281(ns)
Total SCS	30.160	3.398	27.599	3.255	27.315	3.252	106.598	0.000**

** indicate $p < 0.01$ ns - indicate non-significant

Hence, to further explore the relationship between safety climate factors and accident rate in industries studied, the following hypotheses ($H_{0.2}$ to $H_{0.4}$) were formulated.

$H_{0.2}$: There is no significant difference between low accident rate and medium accident rate organizations with respect to each safety climate factor.

$H_{0.3}$: There is no significant difference between medium accident rate and high accident rate organizations with respect to each safety climate factor.

$H_{0.4}$: There is no significant difference between high accident rate and low accident rate organizations with respect to each safety climate factor.

These hypotheses were tested using ANOVA, taking two groups at a time.

6.7.2 Results and discussion

A detailed discussion on the findings of these investigations is presented below.

6.7.2.1 Comparison of low and medium accident rate organizations

Table 6.8 shows that the mean scores of all safety climate factors in low accident rate organizations are relatively higher than that in medium accident rate organizations. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between low accident rate and medium accident rate organizations.

$H_{0.2}$ There is no significant difference between low accident rate and medium accident rate organizations with respect to each safety climate factor.

To test the null hypothesis ($H_{0.2}$), ANOVA F-test was used. The result of this ANOVA test is presented in Table 6.9.

Table 6.9 A comparison of Low accident rate Vs Medium accident rate organizations (Results of ANOVA)

Safety Climate Factors	Low acc. rate		Medium acc. rate		F value	p value
	Mean	SD	Mean	SD		
F1	3.863	0.570	3.244	0.770	219.134	0.000**
F2	4.139	0.461	3.862	0.584	74.412	0.000**
F3	4.569	0.411	4.408	0.489	34.993	0.000**
F4	3.941	0.539	3.723	0.626	38.362	0.000**
F5	2.741	0.931	2.563	0.896	11.143	0.001**
F6	3.963	0.696	3.446	0.702	52.842	0.000**
F7	3.727	0.761	3.220	0.831	114.442	0.000**
F8	3.227	0.987	3.134	1.006	2.540	0.111 (ns)
Total SCS	30.160	3.398	27.599	3.255	175.507	0.000**

** indicate $p < 0.01$ ns - indicate non-significant

From Table 6.9, it can be seen that the low accident rate firms are significantly different from medium accident firms with respect to seven safety climate factors at 0.01 significance level. All these factors are significantly better for low accident rate firms compared to medium accident rate firms. Hence, the null hypothesis $H_{0.2}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety climate factors was accepted at 0.01 level of significance for all factors except F8.

6.7.2.2 Comparison of medium and high accident rate organizations

Table 6.8 shows the mean scores of all safety climate factors in medium accident rate organizations and high accident rate organizations. However, empirical investigation is necessary for making any conclusions about their differences. Therefore, the following hypothesis was tested to find the possible differences between medium accident rate and high accident rate organizations.

$H_{0.3}$: There is no significant difference between medium accident rate and high accident rate organizations with respect to each safety climate factors.

To test the null hypothesis ($H_{0.3}$), ANOVA F-test was used. The result of this ANOVA test is presented in Table 6.10.

Table 6.10 A comparison of Medium accident rate Vs High accident rate organizations (Results of ANOVA)

Safety Climate Factors	Medium acc. rate		High acc. rate		F value	p value
	Mean	SD	Mean	SD		
F1	3.244	0.770	3.158	0.742	3.868	0.049*
F2	3.862	0.584	3.815	0.627	1.901	0.168 (ns)
F3	4.408	0.489	4.444	0.517	1.594	0.207 (ns)
F4	3.723	0.626	3.666	0.667	2.372	0.124 (ns)
F5	2.563	0.896	2.530	0.907	0.412	0.521 (ns)
F6	3.446	0.702	3.393	0.739	1.675	0.196 (ns)
F7	3.220	0.831	3.150	0.843	2.116	0.146 (ns)
F8	3.134	1.006	3.159	1.005	0.191	0.662 (ns)
Total SCS	27.599	3.255	27.315	3.252	2.318	0.128 (ns)

** indicate $p < 0.01$ * indicate $p < 0.05$ ns - indicate non-significant

From Table 6.10, it can be seen that the score of factor F1 (Management attitude and actions for safety) is significantly less in high accident rate organizations compared with medium accident rate organizations. The levels of all other safety climate factors remain the same in the two categories of organizations. Hence, the null hypothesis $H_{0.3}$ received support except for factor F1.

Factor F1 comprise of various safety management practices employed by top management to take care of safety and health of employees. The above finding testifies the importance of various safety management practices in accident prevention.

6.7.2.3 Comparison of high and low accident rate organizations

Table 6.8 shows that the mean scores of all safety climate factors in low accident rate organizations are relatively higher than that in high accident rate organizations. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between low accident rate and high accident rate organizations.

$H_{0.4}$ There is no significant difference between low accident rate and high accident rate organizations with respect to each safety climate factor.

To test the null hypothesis ($H_{0.4}$), ANOVA F-test was used. The result of this ANOVA test is presented in Table 6.11.

Table 6.11 A comparison of High accident rate Vs Low accident rate organizations (Results of ANOVA)

Safety Climate Factors	Low acc. rate		High acc. rate		F value	p value
	Mean	SD	Mean	SD		
F1	3.863	0.570	3.158	0.742	245.069	0.000**
F2	4.139	0.461	3.815	0.627	75.025	0.000**
F3	4.569	0.411	4.444	0.517	15.587	0.000**
F4	3.941	0.539	3.666	0.667	44.317	0.000**
F5	2.741	0.931	2.530	0.907	11.418	0.001**
F6	3.963	0.696	3.393	0.739	132.122	0.000**
F7	3.727	0.761	3.150	0.843	112.028	0.000**
F8	3.227	0.987	3.159	1.005	1.016	0.314(ns)
Total SCS	30.160	3.398	27.315	3.252	159.369	0.000**

** indicate $p < 0.01$ ns - indicate non-significant

From Table 6.11, it can be seen that the low accident rate firms are significantly different from high accident firms with respect to all the safety climate factors except F8, at 0.01 significance level. All these factors are significantly better for low accident rate firms compared to high accident rate firms. Hence, the null hypothesis $H_{0.4}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety climate factors has been accepted at 0.01 level of significance for all factors except F8.

6.8 REALATIOSHIP BETWEEN SAFETY CLIMATE FACTORS AND MANAGEMENT SYSTEM CERTIFICATION

From the review of literature, it appears that studies that explore the relationship between safety climate and system certification has not been conducted so far in India. This finding indicates a gap in literature on safety climate. Considering the increase in industrial accidents and loss to life, material and environment, more and more organizations are voluntarily embracing management system certifications. Hence, there is a need for exploring the relationship between safety climate factors and system certification. The results of the present study would be of great practical relevance to safety managers and decision makers in industrial safety all over the world.

6.8.1 Hypotheses to be tested

To explore the relationship between safety climate factors and system certification, the firms were initially classified into two groups (based on system certification), namely, system certified and non-certified firms. The system certified firms are further classified into ISO certified, OHSAS certified and ISRS certified firms. To test whether there is any difference between the groups (based on system certification), the following hypothesis was formulated.

$H_{0.5}$: There is no significant difference between the groups with respect to each safety climate factor.

6.8.2 Methodology

Out of eight organizations under study, three are not certified, one is OHSAS certified, one is ISRS certified and the remaining three are ISO certified organizations. To test the null hypothesis ($H_{0.5}$), one-way ANOVA F-test, considering all groups together, was used. The result of this test is presented in Table 6.12.

Table 6.12 Difference in the levels of Safety Climate factors with respect to system certification. Results of ANOVA: (all groups taken together)

Safety climate	OHSAS-certified		ISRS-certified		ISO-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD		
F1	3.984	0.543	3.783	0.575	3.291	0.763	3.151	0.755	94.702	0.000**
F2	4.124	0.443	4.149	0.473	3.873	0.606	3.825	0.591	29.425	0.000**
F3	4.544	0.474	4.586	0.364	4.417	0.470	4.422	0.521	10.824	0.000**
F4	3.911	0.544	3.961	0.537	3.722	0.620	3.689	0.657	16.334	0.000**
F5	2.929	0.936	2.617	0.908	2.531	0.883	2.571	0.913	8.914	0.000**
F6	3.954	0.734	3.953	0.671	3.557	0.716	3.320	0.695	73.086	0.000**
F7	3.593	0.767	3.816	0.745	3.261	0.835	3.142	0.833	50.566	0.000**
F8	3.033	0.968	3.355	0.980	3.039	1.021	3.230	0.985	8.517	0.000**
SCS	30.071	3.278	30.219	3.479	27.691	3.441	27.350	3.081	71.632	0.000**

** indicate $p < 0.01$

The results show that there is significant difference between the groups with respect to all the eight safety climate factors at 0.01 significance level. Therefore, the null hypothesis $H_{0.5}$ was not supported, indicating that there is difference between the groups with respect to the safety climate factors. Figure 6.3 shows the mean scores of the eight safety climate factors for the four groups for a comparative study. Hence, to further explore the relationships between safety climate factors and system certifications, the following hypotheses ($H_{0.6}$ to $H_{0.12}$) were formulated.

$H_{0.6}$: There is no significant difference between system certified firms and non-certified firms with respect to each safety climate factor.

$H_{0.7}$: There is no significant difference between OHSAS-18001 certified firms and non-certified firms with respect to each safety climate factor.

$H_{0.8}$: There is no significant difference between ISRS certified firms and non-certified firms with respect to each safety climate factor.

$H_{0.9}$: There is no significant difference between ISO-9001 certified firms and non-certified firms with respect to each safety climate factor.

$H_{0.10}$: There is no significant difference between OHSAS-18001 certified firms and ISRS certified firms with respect to each safety climate factor.

$H_{0.11}$: There is no significant difference between OHSAS-18001 certified firms and ISO-9001 certified firms with respect to each safety climate factor.

$H_{0.12}$: There is no significant difference between ISRS certified firms and ISO-9001 certified firms with respect to each safety climate factor.

These hypotheses were tested using ANOVA, taking two groups of organizations at a time.

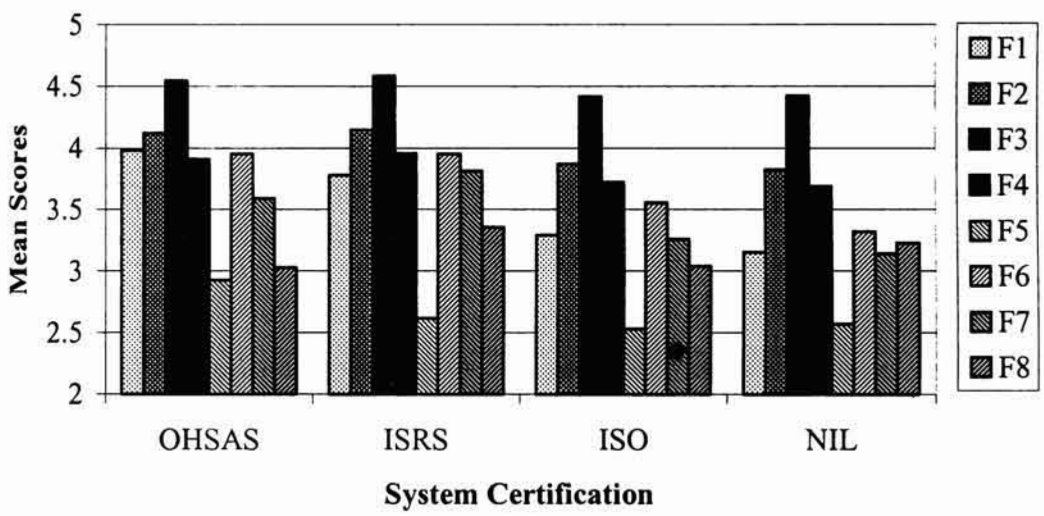

Figure 6.3 System Certification Vs Mean Scores of Safety Climate Factors

6.8.3 Results and discussion

A detailed discussion on the findings of the investigation is presented below.

6.8.3.1 Comparison between Certified and Non-Certified Organizations

The relationship between safety climate factors and system certification was studied by testing the null hypothesis $H_{0.6}$.

$H_{0.6}$: There is no significant difference between system certified firms and non-certified firms with respect to each safety climate factor.

The system certified group includes OHSAS-18001 certified, ISRS certified and ISO-9000 certified organizations. To test the null hypothesis ($H_{0.6}$), ANOVA F-test was used to find whether there is any significant difference between system certified and non-certified groups, with respect to safety climate factors. The results of this ANOVA test are presented in Table 6.13.

Table 6.13 A comparison of System certified and non-certified firms (Results of ANOVA)

Safety climate factors	Certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.519	0.749	3.151	0.755	105.113	0.000**
F2	3.979	0.568	3.825	0.591	31.281	0.000**
F3	4.478	0.454	4.422	0.521	5.834	0.016*
F4	3.809	0.599	3.689	0.657	16.232	0.000**
F5	2.615	0.908	2.571	0.913	0.984	0.321 (ns)
F6	3.715	0.734	3.320	0.695	132.510	0.000**
F7	3.447	0.837	3.142	0.833	58.247	0.000**
F8	3.114	1.011	3.230	0.985	5.834	0.016*
SCS	28.685	3.630	27.350	3.081	65.952	0.000**

** indicate $p < 0.01$ * indicate $p < 0.05$ ns - indicate non-significant

It was found that there are significant differences between the two groups with respect to seven safety climate factors. Therefore, the null hypothesis $H_{0.6}$ was rejected for all factors except F5. Thus, it can be concluded that in certified companies there is a significant and prominent presence of all safety climate factors except F5 when compared to non-certified companies. Even though the difference in F5 is not significant, its value along with all other factors are high in certified firms compared with non-certified firms. This indicates that system certified organizations have better safety climate in them.

It can be concluded that industrial organizations need to go for management system certification (preferably in safety) not only to equip themselves to compete internationally, but also to improve safety standards which will reduce accidents, production loss and workers' compensatory expenses.

6.8.3.2 Comparison between OHSAS 18001 Certified and Non-Certified Organizations

From the above discussions on system certified firms Vs non-certified firms, it appears that firms with OHSAS 18001 standards are better than non-certified firms in all safety climate factors. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis is tested to find the possible differences between OHSAS 18001 certified and non-certified organizations.

$H_{0.7}$: There is no difference between OHSAS-18001 certified firms and non-certified firms with respect to each safety climate factor.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 6.14.

Table 6.14 Comparison of OHSAS 18001 certified Vs Non-certified organizations (Results of ANOVA)

Safety climate factors	OHSAS-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.984	0.543	3.151	0.755	182.969	0.000**
F2	4.124	0.443	3.825	0.591	38.342	0.000**
F3	4.544	0.474	4.422	0.521	7.784	0.005**
F4	3.911	0.544	3.689	0.657	16.508	0.000**
F5	2.929	0.936	2.571	0.913	20.778	0.000**
F6	3.954	0.734	3.320	0.695	111.745	0.000**
F7	3.593	0.767	3.142	0.833	41.358	0.000**
F8	3.033	0.968	3.230	0.985	5.510	0.019*
SCS	30.071	3.278	27.350	3.081	104.429	0.000**

** indicate $p < 0.01$ * indicate $p < 0.05$

From Table 6.14, it can be seen that the OHSAS 18001 certified firms are significantly different from non-certified firms with respect to all the eight safety climate factors. All these factors are significantly better for OHSAS certified firms compared to non-certified firms. Hence the null hypothesis $H_{0.7}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety climate factors has been accepted at 0.01 level of significance.

From the results it can be concluded that OHSAS 18001 certification helps the organization to have improved safety climate to take care of safety of its employees.

6.8.3.3 Comparison between ISRS Certified and Non-Certified Organizations

From the discussions on system certified firms Vs non-certified firms, it appears that safety climate in firms with ISRS standards is better than that in non-certified firms. Such conclusions cannot be arrived at with empirical investigations. Therefore, the following hypothesis was tested to find the possible differences between ISRS certified and non-certified organizations.

$H_{0.8}$: There is no significant difference between ISRS certified firms and non-certified firms with respect to each safety climate factor.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 6.15.

From Table 6.15, it can be seen that the ISRS certified firms are significantly different from non-certified firms with respect to six safety climate factors at 0.01 significance level. All these factors are significantly better for ISRS certified firms compared to non-certified firms. Factors F5 and F8 are better in ISRS firms, but the difference in not statistically significant. Hence, the null hypothesis $H_{0.8}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety climate factors has been accepted at 0.01 level of significance for all factors except F5 and F8.

Table 6.15 Comparison of ISRS certified Vs Non-certified organizations (Results of ANOVA)

Safety climate factors	ISRS-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.783	0.575	3.151	0.755	148.795	0.000**
F2	4.149	0.473	3.825	0.591	63.097	0.000**
F3	4.586	0.364	4.422	0.521	21662	0.000**
F4	3.961	0.537	3.689	0.657	35.419	0.000**
F5	2.617	0.908	2.571	0.913	0.476	0.491(ns)
F6	3.953	0.671	3.320	0.695	160.452	0.000**
F7	3.816	0.745	3.142	0.833	130.900	0.000**
F8	3.355	0.980	3.230	0.985	3.087	0.079(ns)
SCS	30.219	3.479	27.350	3.081	153.933	0.000**

** indicate $p < 0.01$ ns - indicate non-significant

6.8.3.4 Comparison between ISO 9000 Certified and Non-Certified Organizations

From the discussions on system certified firms Vs non-certified firms, it appears that ISO certified firms are better than non-certified firms in safety climate. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between ISO certified and non-certified organizations.

$H_{0.9}$: There is no significant difference between ISO certified firms and non-certified firms with respect to each safety climate factor.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 6.16.

From Table 6.16, it can be seen that the ISO certified firms are significantly different from non-certified firms with respect to four (F1, F6, F7 and F8) out of the eight safety climate factors at 0.01 significance level. F1, F6 and F7 are significantly better for ISO certified firms compared to non-certified firms whereas, F8 is significantly better in non-certified compared to ISO certified firms. Factors F2, F3, F4 and F5 have same levels in the two categories of firms. Three of these four factors are mainly behaviour / attitude oriented, and support the general belief that the people of Kerala have higher level of motivation and safety awareness than people in many other states of India. These findings also reiterate that traditional safety management programmes (used by non-certified firms) do not always improve the results of safety because they are centered exclusively on the technical requirements and on obtaining short-term results (Weinstein, 1996)

Table 6.16 Comparison of ISO certified Vs Non-certified organizations (Results of ANOVA)

Safety climate factors	ISO-certified		Non-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.291	0.763	3.151	0.755	11.669	0.001**
F2	3.873	0.606	3.825	0.591	2.221	0.136(ns)
F3	4.417	0.470	4.422	0.521	0.036	0.849(ns)
F4	3.722	0.620	3.689	0.657	0.906	0.341(ns)
F5	2.531	0.883	2.571	0.913	0.698	0.404(ns)
F6	3.557	0.716	3.320	0.695	38.875	0.000**
F7	3.261	0.835	3.142	0.833	6.978	0.008**
F8	3.039	1.021	3.230	0.985	12.418	0.000**
SCS	27.691	3.441	27.350	3.081	3.772	0.050*

** indicate $p < 0.01$ * indicate $p < 0.05$ ns - indicate non-significant

Hence, the null hypothesis $H_{0.9}$ was partially rejected and the alternate hypothesis proposing a difference in the levels of safety climate factors has been partially accepted at 0.01 level of significance for F1, F6, F7 and F8.

6.8.3.5 Comparison between OHSAS 18001 Certified and ISRS Certified Organizations

From Table 6.12, it appears that firms with OHSAS standards are better than ISRS certified firms in all safety climate factors. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between OHSAS certified and ISRS certified organizations.

$H_{0.10}$: There is no significant difference between OHSAS certified firms and ISRS certified firms with respect to each safety climate factor.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 6.17.

From Table 6.17, it can be said that the OHSAS certified firms are significantly different from ISRS certified firms with respect to four safety climate factors (namely, F1, F5, F7 and F8) out of the eight safety climate factors, at 0.01 significance level. F1 and F5 are better in OHSAS certified firms whereas F7 and F8 are better in ISRS certified firms. There appears to be no significant difference with respect to F2, F3, F4 and F6. Therefore the null hypothesis $H_{0.10}$ was partially accepted.

Table 6.17 Comparison of OHSAS 18001 certified Vs ISRS certified organizations (Results of ANOVA)

Safety climate factors	OHSAS-certified		ISRS-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.984	0.543	3.783	0.575	12.989	0.000**
F2	4.124	0.443	4.149	0.473	0.294	0.588 (ns)
F3	4.544	0.474	4.586	0.364	1.049	0.306 (ns)
F4	3.911	0.544	3.961	0.537	0.872	0.351 (ns)
F5	2.929	0.936	2.617	0.908	11.639	0.001**
F6	3.954	0.734	3.953	0.671	0.000	0.989 (ns)
F7	3.593	0.767	3.816	0.745	8.815	0.003**
F8	3.033	0.968	3.355	0.980	11.044	0.001**
SCS	30.071	3.278	30.219	3.479	0.191	0.663 (ns)

** indicate $p < 0.01$ ns - indicate non-significant

6.8.3.6 Comparison between ISRS Certified and ISO Certified Organizations

From Table 6.12, it appears that firms with ISRS standards are better than ISO certified firms in all safety climate factors. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between ISRS certified and non-certified organizations.

$H_{0.11}$: There is no significant difference between ISRS certified firms and ISO certified firms with respect to each safety climate factor.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 6.18.

Table 6.18 Comparison of ISRS certified Vs ISO certified organizations (Results of ANOVA)

Safety climate factors	ISRS-certified		ISO-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.783	0.575	3.291	0.763	86.204	0.000**
F2	4.149	0.473	3.873	0.606	42.687	0.000**
F3	4.586	0.364	4.417	0.470	26.648	0.000**
F4	3.961	0.537	3.722	0.620	29.058	0.000**
F5	2.617	0.908	2.531	0.883	1.708	0.192 (ns)
F6	3.953	0.671	3.557	0.716	57.782	0.000**
F7	3.816	0.745	3.261	0.835	85.332	0.000**
F8	3.355	0.980	3.039	1.021	17.826	0.000**
SCS	30.219	3.479	27.691	3.441	97.729	0.000**

** indicate $p < 0.01$ ns - indicate non-significant

From Table 6.18, it can be concluded that the ISRS certified firms are significantly different from ISO certified firms with respect to seven safety climate factors at 0.01 significance level. All these factors are significantly better for ISRS certified firms compared to ISO certified firms. Factor F5 which is not significantly different however shows better values in ISRS firm. Hence, the null hypothesis $H_{0.11}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety management practices has been accepted at 0.01 level of significance.

6.8.3.7 Comparison between OHSAS 18001 Certified and ISO Certified Organizations

From Table 6.12, it appears that firms with OHSAS 18001 standards are better than ISO certified firms in all safety climate factors. However, empirical investigation is necessary for making such conclusions. Therefore, the following hypothesis was tested to find the possible differences between OHSAS 18001 certified and ISO certified organizations.

$H_{0.12}$: There is no significant difference between OHSAS 18001 certified firms and ISO certified firms with respect to each safety climate factor.

One-way ANOVA F-test was used for testing the difference between these groups, and the results are presented in Table 6.19.

Table 6.19 Comparison of OHSAS 18001 certified Vs ISO certified organizations (Results of ANOVA)

Safety climate factors	OHSAS-certified		ISO-certified		F value	p value
	Mean	SD	Mean	SD		
F1	3.984	0.543	3.291	0.763	122.120	0.000**
F2	4.124	0.443	3.873	0.606	25.380	0.000**
F3	4.544	0.474	4.417	0.470	9.731	0.002**
F4	3.911	0.544	3.722	0.620	12.911	0.000**
F5	2.929	0.936	2.531	0.883	26.318	0.000**
F6	3.954	0.734	3.557	0.716	40.474	0.000**
F7	3.593	0.767	3.261	0.835	21.742	0.000**
F8	3.033	0.968	3.039	1.021	0.005	0.0941(ns)
SCS	30.071	3.278	27.691	3.441	64.907	0.000**

** indicate $p < 0.01$ ns - indicate non-significant

From Table 6.19, it can be inferred that the OHSAS 18001 certified firms are significantly different from ISO certified firms with respect to seven safety climate factors at 0.01 significance level. All these factors are significantly better for OHSAS 18001 certified firms compared to ISO certified firms. Factor F8 does not differ among this category of firms. Hence, the null hypothesis $H_{0.12}$ was rejected and the alternate hypothesis proposing a difference in the levels of safety climate factors has been accepted at 0.01 level of significance except for all factors other than F8.

6.9 SUMMARY

The responses collected through the questionnaire which was used for measuring safety management practices, determinants and components of safety performance along with few more questions to measure safety of work environment were subjected to exploratory principal component factor analysis using SPSS 10 statistical software to determine the underlying factors or dimensions in safety climate. 75% of the data (randomly selected) was used for this analysis and the remaining 25% was kept aside for validation purpose.

The factor analysis gave 8 factors capable of explaining 52.147% of the total variance. The internal scale reliability (Cronbach Alpha) values for all factors except "Priority for safety over production" were found to be acceptable (above 0.60). Running Confirmatory Factor Analysis (CFA) on the remaining 25% of the data, it was found that the factor structure obtained in exploratory factor analysis was very well reflected in this data (TLI and CFI values were above 0.90).

Overall, the safety climate factors obtained were well acceptable. Subsequent analysis revealed that the eight safety climate factor scores and total safety climate scores differ significantly among organizations indicating that organizations have different levels of safety climate in them. All the eight safety climate factors were found to be negatively correlated to self-reported accident rates with five of them showing significant correlations. "Workers' participation and commitment to safety" emerged as the significant predictor of self-reported accident rate with highest correlation of –0.867 at significance level beyond 0.005.

Organizations with lower accident rate were found to have significantly higher levels of safety climate factor scores (except for "Risk justification") compared with medium and high accident rate organizations. Same levels of safety climate factor scores exist among medium and high accident rate organizations, except for "Management attitude and actions for safety".

Comparing organizations grouped on the basis of system certification, it is found that there is significant difference in the levels of safety climate factor scores in them. Management system certified organizations have better safety climate factors compared with non-certified firms, except for "Safeness of work environment". ISO certified and non-certified organizations have same levels in four out of eight safety climate factors. Similarly, OHSAS 18001 and ISRS certified organizations were found to have significant difference in only four safety climate factors.

Overall, it is concluded that safety climate predict accident rate and organizations with lower accident rates and OHSAS 18001 and ISRS certifications have better safety climate.

CHAPTER 7

SAFETY CLIMATE IN ENGINEERING AND CONSTRUCTION INDUSTRIES

Section 7.1 examines how well the safety climate model that emerged from chemical/process industry fit the data collected from engineering industry, followed by an exploratory factor analysis to determine safety climate factor structure prevailing in engineering industry. Similar analyses for construction industry are also presented in Section 7.2. Section 7.3 presents a detailed discussion on safety climate models of chemical/process, engineering and construction industries. Section 7.4 contains summary of this chapter.

Critical safety management practices, determinants of safety performance and components of safety performance have been identified and validated in the previous chapters. Their inter-relationships were also investigated by proposing safety performance models. Their relationships with accidents and management system certification were examined in the validation process. Subsequently, the underlying factors of safety climate were explored and their relationships with accidents and system certification in industries were also investigated. Since safety is a key operating characteristic in chemical/process industries, the study was conducted in eight major chemical/process industrial units in Kerala.

This part of the study investigates whether safety climate factors in engineering and construction industries are similar to those obtained in chemical/process industry.

7.1 ENGINEERING INDUSTRY

When we compare chemical/process industry with manufacturing/engineering industry, one difference becomes evident. It is possible to stop a manufacturing system running out of control by simply "pulling the plug" thereby shutting down the production line whereas reactions are not so easily managed or controlled in a chemical/process industry. Accidents at Bhopal and Chernobyl are examples of processes that were impossible to control within a time parameter to prevent death and destruction. That is why safety is given paramount importance and becomes a defining characteristic in chemical/process industries (Hofmann et al., 1995).

Even though the types of hazards are different, engineering industries have machinery, material-handling equipments and associated production activities that require constant attention and care, which when absent or deficient can cause serious accidents. Hence, the safety management practices, determinants and components of safety performance are equally applicable in these industries also.

There are only a few large manufacturing/engineering industrial units with safety departments in central part of Kerala and only two companies granted permission for this study. The questionnaire presented and discussed earlier was used for the survey and data collection was completed in the year 2004. In the first organization, 500 questionnaires were distributed among the workers and supervisory staff and 225 filled-up forms were returned with a response rate of 45%. In the second organization, only 89 completed forms were returned out of 300 with a response rate of 35%. Thus a total of 314 completed forms with a response rate of 40% were available for the study.

7.1.1 Confirmatory Factor Analysis

As the validity of a safety climate model depends in part on its applicability to groups other than workers from a particular type of industry (in this case chemical/process industry), it was decided to test the eight factor safety climate model on workers in engineering industry. Confirmatory factor analysis technique using maximum likelihood method was adopted for this purpose, using AMOS 4 statistical software. In confirmatory factor analysis, the available model is tested statistically examining the degree to which it fits with the new data.

Convergent validity of the safety climate model was assessed by computing Bentler-Bonnet Non-Normed Fit Index (NNFI or TLI), (Bentler and Bonnet, 1980) and unidimensionality was assessed by computing Comparative Fit Index (CFI) (Byrne, 1994) (Detailed discussion about CFA and fit indices have already been presented in Chapter 3). The results of this analysis are presented in Table 7.1.

Table 7.1 Results of CFA with data from Engineering Industry – Fit indices.

Data	χ^2	DF	χ^2/ DF	p	CFI	TLI
Engg. Industry	2476.486	1349	1.836	0.000	0.832	0.822

The fit indices CFI and TLI are below the minimum required value of 0.9 indicating that model does not fit the data. This means that the proposed safety climate model is not valid in engineering industry. Hence, it was decided to run an exploratory factor analysis to determine the safety climate factors applicable to engineering industry.

7.1.2 Exploratory Factor Analysis

The data collected from engineering industrial units were deemed appropriate for factor analysis, as the minimum case-to-variable ratio of 5:1 (Hair et al., 1998) was available. This data was subjected to principal component factor analysis using SPSS 10 software package. A varimax rotation was performed to enhance factor interpretability. Those items, which failed to attain a minimum correlation of 0.3 with any other item, were removed *initially. The factor loading cut-off was fixed at 0.4 as recommended by Hair et* al. (1998). The step-by-step analysis resulted in removal of 26 items from the total of 62 items. This procedure finally resulted in 5 factors with eigen values greater than one which explained 51.89 % of the total variance. Kaiser-Meyer-Oaklin measure of sampling adequacy (KMO value) obtained was 0.932, which was above the meritorious value of 0.8 (Hair et al., 1998). Bartlett Test of Sphericity was significant ($\chi^2 = 4715$, degrees of freedom = 630, $p < 0.001$), indicating that correlations exist among some of the response categories. There were totally 36 items in the scale. The five factors so obtained with their names, number of items in each factor and variance explained are presented in Table 7.2.

Table 7.2 Results of factor analysis showing factor names, no. of items, % variance explained and Cronbach alpha values

No	Factor name	No of items	% Variance explained	Cronbach Alpha (α)
1	Management attitude and actions for safety	20	30.423	0.9437
2	Workers' knowledge and compliance to safety	5	8.101	0.7228
3	Safety of work environment	4	5.187	0.7006
4	Risk justification	3	4.369	0.6347
5	Workers' attitude towards safety	4	3.810	0.6664

The internal-scale reliability (Cronbach Alpha) of the scale was estimated as 0.9256, which is above the acceptable limit of 0.6 for exploratory field research (Hair et al., 1998; Gregory, 1996). The reliability coefficients across items in each factor were also found to be above 0.6 for all factors (Table 8.2). Overall, the safety climate model obtained has high degree of reliability.

7.2 CONSTRUCTION INDUSTRY

Construction sites in developing countries are 10 times more dangerous than in industrialized nations and the fatality rate in developed countries is almost half of that in India. About 2 crore construction workers are estimated to be working in the industry in India and an estimated 1580 workers per one lakh in this sector are killed in accidents every year at workplace (Sinha, 2002). This highly unorganized sector is the second largest employer after agriculture and the profile of the labor is characterized by the agrarian background, migratory nature and a very high degree of transitory employment. General adverse physical/environmental operating conditions and the associated high-risk potential makes construction different from other industries. These operating conditions, most of them unique to construction industry, have an influence on the safety performance. Non-availability of adequate number of trained/skilled manpower, temporary nature of work, seasonal employment of workers and time constraints are some of the difficulties experienced in this industry. Till 1996, there was no specific legislation applicable to construction industry in India. In the absence of statutory requirements, adequate attention was not given to safety at construction sites. As on today, 'Building and Other Construction worker's Act, 1996', 'Central Rules, 1998' and 'Kerala State Rules, 1998' lay down the statutory requirements to look after workers' safety at construction sites in Kerala.

Laws and regulations will be important as parts of the infrastructure of safety management, but beliefs and actions have a stronger influence upon the safety climate of construction sites (Langford et al., 2000). Wilson (1989) points out that the paradigms used for manufacturing industry are not directly transferable to the construction industry, which is based on organic organization rather than the mechanistic systems of manufacturing sector. Even though safety management practices do exist in construction industry, knowledge is acquired on the site by the learning process of 'trial and error'. The resultant knowledge and experience is the means by which safe and unsafe acts or conditions are assessed. In the absence of other means of assessing danger, experience becomes the most powerful tool for motivating or demotivating safe behaviour (Wilson, 1989).

The earlier questionnaire was used for studying the safety climate in construction industry also and study was restricted to the workmen from multi-storeyed (6 storeys and above) building construction sites in Kerala. When approached, 3 construction companies granted permission for conducting the survey. Out of many sites owned by these 3 groups, 10 sites were selected which were at different stages of execution. The data collection was completed in the year 2004 and a total of 312 completed forms were received with a response rate of 80%.

7.2.1 Confirmatory Factor Analysis

To verify whether the safety climate factor structure in construction industry is identical with the one obtained from chemical/process industry, confirmatory factor analysis was run on the data collected from construction industry. The results presented in Table 7.3 reveal that the fit indices are far below acceptable limit of 0.9 testifying that the safety climate model does not fit the data.

Table 7.3 Results of CFA with data from Construction Industry – Fit indices.

Data	χ^2	DF	χ^2/ DF	p	CFI	TLI
Construction Industry	5139.537	1349	3.81	0.000	0.558	0.584

This indicates that the proposed safety climate model is not valid in construction industry. Hence it was decided to run an exploratory factor analysis to determine the safety climate factors applicable to construction industry.

7.2.2 Exploratory Factor Analysis

The data collected from construction workers were deemed appropriate for factor analysis, as the minimum case-to-variable ratio of 5:1 (Hair et al., 1998) was available. This data was subjected to principal component factor analysis using SPSS 10 software package. A varimax rotation was performed to enhance factor interpretability. Those items, which failed to attain a minimum correlation of 0.3 with any other item, were removed initially. The factor loading cut-off was fixed at 0.4 as recommended by Hair et al. (1998). The step-by-step analysis resulted in removal of 33 items from the total of 62 items. This procedure finally resulted in 5 factors with eigen values greater than one which explained 59.038 % of the total variance. Kaiser-Meyer-Oaklin measure of sampling adequacy (KMO value) obtained was 0.854, which was above the meritorious value of 0.8 (Hair et al., 1998). Bartlett Test of Sphericity was significant (χ^2 = 4393, degrees of freedom = 406, p < 0.001), indicating that correlations exist among some of the response categories.

There were totally 29 items in the scale. The five factors with their names, number of items in each factor and variance explained are presented in Table 7.4. The internal-scale reliability (Cronbach Alpha) of the scale was estimated as 0.8794, which is above the acceptable limit of 0.6 for exploratory field research (Hair et al., 1998; Gregory, 1996). The reliability coefficients across items in each factor were also found to be above 0.6 for all factors (Table 7.4). Overall, the safety climate model obtained was found to have high degree of reliability.

Table 7.4 Results of factor analysis showing factor names, no. of items, % variance explained and Cronbach alpha values

No	Factor name	No of items	% Variance explained	Cronbach Alpha (α)
1	Management attitude and actions for safety	14	28.042	0.9302
2	Workers' motivation and actions for safety	5	11.879	0.7250
3	Safety knowledge	4	9.237	0.7973
4	Apathy of workers	4	5.293	0.7349
5	Risk justification	2	4.587	0.6909

7.3 DISCUSSION

Safety climate model that emerged from engineering industry consists of five factors, which explains 52% of the total variance. These five factors are also present in the eight-factor safety climate model obtained from chemical/process industry. Even though numbers of items in each factor are slightly different between the two models, they convey the same meaning and underlying dimension.

The five factors obtained in construction industry have only three factors that are obtained in chemical/process industry. The other two factors, namely, 'Safety Knowledge' and 'Apathy of Workers' are new factors. The peculiar operating conditions, most of them unique to construction industry, such as knowledge accumulation by trial and error and experience and hazard assessment based on experience etc. (Wilson, 1989) justify these factors.

Three factors seen in chemical/process industry, namely, 'Workers' participation and commitment to safety', ' Emergency preparedness in the organization' and 'Priority for safety over production' failed to emerge in both engineering and construction industries. These factors are more associated with high-risk chemical/process industries and hence can be justified.

In many previous studies, differences in safety climate factor structures were observed while using same questionnaire in different industrial sectors and different populations. Dedobbeleer and Beland (1991) found such difference in manufacturing and construction workers and postulated that the difference was due to different industry sampled.

From this study, it is seen that, three factors are common to the safety climate models of all the three industries. This finding is in tune with Glendon and Litherland (2001) who have postulated that, "although the same safety climate factors will not apply to all organizations, some generic safety climate factors do exist and they may be stable across industries".

7.4 CONCLUSION

Safety climate factor structure from chemical/process industry was tested using responses collected from engineering and construction industry. It was found that, in neither case, the model already obtained for chemical industry fit the data. Therefore, exploratory factor analysis was run to determine the safety climate factors in engineering and construction industries separately. Only five factors emerged in engineering industry and they were same as five factors out of eight, present in chemical/process industry. In the case of construction industry, five factors were obtained and two of them, namely, "Safety Knowledge" and "Apathy of Workers" were new ones.

Three factors were found to be common for all the three types of industries, testifying that some generic safety climate factors do exist and they are independent of type of industry.

CHAPTER 8

SUMMARY AND CONCLUSION

This Chapter gives a summary of the thesis. The research findings are summarized in Section 8.1. Section 8.2 explains the limitations of the present study. Scope for future work is suggested in Section 8.3 and Section 8.4 contains the conclusion drawn from the study.

Safety awareness that is spreading to all walks of life and all types of organizations has made 'Safety Management' a potential area of research. While considerable research has been done on the topics of safety management and safety culture/climate in developed countries, such work is not to be seen reported in India. Globalization and economic reforms warrants Indian industries to adopt better safety management to stay competitive in international markets. It is observed that industrial accidents, associated financial losses, and compensation claims eat away considerable portion of the profit earned by organizations. These also damage the reputation of organization and lower the morale of the employees. Captains of industries are still faced with the challenge of understanding the key issues in safety management so as to provide healthy and safe work environment to their employees. This underscores the need to study the various factors that influence industrial safety management, especially in high-risk industry such as chemical/process industry.

The survey of literature on safety management revealed that application of quality integrated safety management practices have enabled different types of industries to gain better control over accidents and injuries, and also to improve production and employee satisfaction and thus strengthen their level of competitiveness. Therefore, it is evident that a clear understanding of the critical factors in safety management would help the implementation of management practices to improve safety of employees and enable better control over accidents and injuries. However, empirical research works on this topic are quite few in Indian industries.

Moreover, it appears that the relationship between safety management practices and determinants of safety performance has not yet been examined rigorously. Similar is the case of relationship between determinants and components of safety performance. The impact of personal attributes of employees on safety performance variables is an area worth exploring from behavioral science angle also. Therefore, in this research, an attempt was made to unearth the critical safety management practices, determinants of safety performance and components of safety performance. This study also investigated their relationships with the help of an extensive empirical research.

The ultimate aim of safety management is to reduce accidents. As the level of safety management increases, accident rate has to reduce. This research also explored the predictive validity of safety management practices along with comparison of safety management practices in industrial units grouped based on accident rate.

More and more industries in India are embracing safety specific management system certifications such as OHSAS 18001 and ISRS in addition to ISO 9001 series quality certification. The effects of system certifications on safety management practices and determinants and components of safety performance, also appear to be unexplored. System certification becomes meaningful and useful if only it reflect in safety performance outcomes such as accidents and injuries. Nevertheless, empirical evidence appears to be lacking to support these beliefs. Therefore, attempts were made in the current study to investigate the impact of system certification on safety management practices as well as determinants and components of safety performance.

The relationships between the antecedents, determinants and components of safety performance are complex in nature with multiple interrelated dependence relationships. Survey of literature revealed that this area has not yet been thoroughly investigated. Hence, attempt was made in this study, to model safety performance using Structural Equation Modelling technique.

Safety climate is regarded as a manifestation of safety culture of an organization and is a more tangible expression of the workplace characteristics and attitude of employees towards safety at given point of time. This 'snap-shot' of safety culture of an organization has distinct advantages over other safety measures. Safety climate studies are widely used in developed countries to determine the underlying factor structure, which can be a guide for the design of appropriate safety interventions to improve safety performance of employees. However, safety climate studies are at infant stage in India, with safety management itself gaining attention only very recently. Hence, an attempt was made in this research, to determine the underlying safety climate factors and to investigate their relationships with accident rate and system certification in chemical/process industry.

Researches in safety climate, covering wide variety of industries in various parts of the world reveal that, safety climate factors are not universally stable, but are mainly culture and industry dependent. But, some researchers argue that, still some generic safety climate factors do exist, which are independent of industries. Since this study was carried out in chemical/process industry, an attempt was also made to examine the extent to which the data collected from construction and engineering industry fit the already available safety climate factor structure. Subsequently, safety climate factors in construction and engineering industries were determined to locate and identify the generic safety climate factors.

8.1 RESEARCH CONTRIBUTIONS

The contributions of this research work are summarized as follows:

- Identified a list of six critical safety management practices, two determinants of safety performance and two components of safety performance, by addressing the various facets (human and non-human aspects) of safety management.

- Developed an instrument for measuring the levels of safety management practices, determinants and components of safety performance in organization, followed by extensive empirical tests for validity and reliability. Practitioners can use the instrument to measure the levels of safety management in their organizations. This use could provide vital information to the decision-makers for designing and developing safety intervention programs for enhancing their safety performance.

- This research demonstrated empirical validation of the measurement instrument to enrich the subject of theory building (especially in the context of scarcity of empirical research works in safety management literature).
- A holistic framework for safety management in high-risk industries is proposed in this research. This effort would help to provide a conceptual clarity in understanding the related issues and the critical factors of safety management.
- The six safety management practices identified in this research were found to be negatively correlated to self-reported accident rate. 'Worker Involvement' emerged as a key predictor of accident rate showing strongest correlation. This suggests that, 'Worker Involvement' need to be given high priority for success of any safety program implementation.
- Low accident rate organizations have significantly higher levels of safety management practices, determinants and components of safety performance, compared with medium and high accident rate organizations. This finding not only validated the measurement instrument, but also reiterated that management initiatives for better safety management are rewarded by safer work environment.
- Medium accident rate organizations were found to possess significantly higher levels of 'Management Commitment', 'Safety Rules and Procedures' and 'Safety Promotion Policies' compared with high accident rate organizations. Since these three management practices are mostly supervisor/first line officer centered, this finding testified the significance of their role in accident prevention in industry.
- Comparison of safety management practices, determinants and components of safety performance in industrial units grouped based on accident rate and system certification adds to the not-so-rich research literature in this field.
- Management system certified organizations were found to have significantly higher levels of safety management practices, determinants and components of safety performance, compared with non-certified organizations. This finding

testifies that industries get remarkable benefit and advantage in safety performance by acquiring management system certification.

- ISO certified and non-certified organizations were found to have same level of 'Safety Promotion Policies'. This reveals that, non-certified firms are adopting traditional safety management by encouraging workers to perform their work safely by offering incentives and rewards.

- OHSAS 18001 certified organization was found to have highest level of safety management practices. Hence, this research recommends OHSAS 18001 certification for adoption in Indian industries.

- It was found that 'Safety Training' predicts both determinants of safety performance, namely, 'Safety knowledge (KNO)' and 'Safety motivation (MOT)'. It was also found that both KNO and MOT decrease with increase in age of employees. This indicated that, to maintain higher level of KNO and MOT among employees, management need to conduct regular training programs and participation must be made compulsory for all groups of workers. The high predictive capacity of KNO and MOT on both 'Safety Compliance (COM)' and 'Safety Participation (PAR)' reiterates the need of the above.

- The safety performance model that was finally accepted revealed the inter-relationships between various safety management practices, determinants and components of safety performance. This can guide safety professionals in designing safety programs for specific purposes targeting improvements in desired areas. This will add to the literature of structural equation modelling in industrial safety, which is very scarce, especially from developing Asian nations.

- Safety climate factors reveal the underlying dimensions that are significant in influencing safety in workplace. It not only gives safety management practices and work place characteristics, but also the attitudes and beliefs of workers that influence safety. Hence, practitioners can design safety programs for improving or strengthening these latent factors, which will finally contribute for better safety performance. This research revealed the following eight factors in safety climate:

Management attitude and actions for safety, Workers' knowledge and compliance to safety, Workers' attitude towards safety, Workers' participation and commitment to safety, Safeness of work environment, Emergency preparedness in the organization, Priority for safety over production and Risk justification.

- It was found that all the eight safety climate factors and the total score differ significantly among organizations indicating that organizations have different levels of safety climate in them. 'Workers' participation and commitment to safety' emerged as the significant predictor of self-reported accident rate with strongest correlation.
- Management system certified firms were found to have better safety climate, reaffirming the need to have system certification in industry.
- On determining safety climate factors in construction and engineering industry, it was found that they differ from those obtained from chemical/process industry. Still, it testified the theory that few generic safety climate factors, which are independent of type of industry, do exist.
- The present work adds value to the literature of safety management as the work is carried out in a developing country like India, where safety management is in a budding stage.

8.2 LIMITATIONS OF THE PRESENT WORK

As mentioned earlier, much work has not been done in this area in India. Hence, this research design had to be based mainly on work reported internationally. However, discussions with experts in the field were used to modify the research design to suit the Indian environment. India being a multi-cultural country, it was thought appropriate to study industries from a single cultural segment. This segment was chosen as the state of Kerala for reasons of familiarity of the researcher with the culture and the industry.

Kerala state being industrially not well developed, only eight large chemical/process industrial units were available for the survey in this study. The two fold reasons for this are the existence of a lower number of industrial units and the hesitation of some units in participating in a study on safety, which is a sensitive issue. Limiting the number to eight resulted in the handicap of not being able to carryout correlations and some more predictive analysis with a high degree of reliability.

Availability of a small sample size reduced the number of organizations with OHSAS 18001 and ISRS certifications available in the samples to one each, which is definitely a limitation when one wants to generalize the results obtained in the study. The impact of this was contained to some extent by taking a large sample size from each of the organizations in order to understand and determine the characteristics of each organization.

Despite the above limitations of the study, with proper use of statistical tools and rigour of research methodology adopted, this research has been able to make contributions.

8.3 SCOPE FOR FUTURE RESEARCH

This work being one of the earliest ones in this area in the country has to stop at a place which leaves much more to be done by future researchers. This work effectively demonstrated the researchability and usefulness of this important area of research. Emphasis was given to large chemical/process units in this research for reasons stated earlier. It is possible and even desirable to extend this type of work to cover other industrial sectors where safety plays an important role. Another dimension in which this research could be extended is to cover culturally different segments by covering another state.

This work reveals clearly the importance of worker involvement in safety management, which in turn determines safety performance. It is a proven fact that behavioural studies can be used to study people related parameters. Worker involvement, being people based, could be studied from behavioural science angle also.

8.4 CONCLUSION

Attempting to do a work in the area of safety management in India posed a challenge. Identifying the objectives of the research, when not enough published material is available, was the first challenge. This was overcome by the use of international literature survey and logical extension of the research findings and local expert opinion to understand the problem area and lay down objectives of the research. Formulation of research methodology was much easier. Design of the tool for data collection posed some challenge since the factors to be proved and questions to be asked to elicit response had to be appropriate for the respondents. When it came to sample selection and questionnaire administration, the delicacy of revealing safety related information and opinion posed a major hurdle. Some companies refused permission for this research. In those that permitted also, sample selection became an issue. This, however, became a boon in disguise helping the researcher to collect the response of a large number of participants rather than going for sampling. The large sample size from each unit helped to determine scores from that unit much more accurately. Differences between units became clearer and could be stated with more reliability. A wide variety of safety management level was to be seen even in the limited sample industrial units studied. This indicates clearly that safety management practices are different in different organizations with that in some being superior to that in others.

This study has established the importance of understanding the factors that influence safety management so as to enable industrial units at lower levels to improve their performance. This research could bring out the factors in chemicals/process industries and could also show that they were different from that in construction and engineering industries. Details of the analysis and findings presented earlier in this thesis will be of use to both researchers and practising managers. The objectives laid down in the beginning of the research could be finally achieved to a high degree of satisfaction. Like in all research, this work also has its limitations mentioned earlier. It also has laid ground for much more work in this area in future. This research was a very important learning experience for the researcher and has significantly contributed to his appreciation for the area of safety management and research methodology.

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