

Evaluation of Safety Management System Effectiveness in a Liquefied Natural Gas Company

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How to cite this paper: Ali, P.O., Wyse, M.E., Odeniyi, K.O., Oludele, O.E., Ejomafuvwe, E., John, A. and Faremi, O.B. (2022) Evaluation of Safety Management System Effectiveness in a Liquefied Natural Gas Company. *Open Journal of Safety Science and Technology*, 12, 31-42.

<https://doi.org/10.4236/ojsst.2022.122003>

Received: April 2, 2022

Accepted: May 28, 2022

Published: May 31, 2022

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Abstract

This study was aimed at evaluating the effectiveness of safety management system (SMS) in a liquefied natural gas company. A 5-point Likert questionnaire ranging from “strongly disagree to strongly agree” questions was used to evaluate workers’ perception of the implication of safety management system in the organisation. The OHSAS 18001 internal audit checklist was also used to measure the level of compliance with the requirements of the SMS. Secondary data was obtained from document and safety report of the case study. The data was collated and subjected to descriptive statistics, t-test and row and column contingency (R & C) table to evaluate the relationship between safety performance and compliance. For compliance to SMS: General requirements, 91%; Health and Safety Policy, 95%; Planning, 93%, Implementation and Operation, 98%; Audit, 98%; and Management Review, 93%. The overall average level of compliance was 95%. 100 respondents participated in the questionnaire, 64 males and 36 females; 68 technical personnel and 32 nontechnical respondents. Descriptive analysis of employees’ perception resulted in: Safety satisfaction and feedback, 4.113; Training and competence, 4.182; Safety reporting and investigation, 4.212; Work Duties/Pressure, 3.989; Management commitment, 4.098; Safety communication, 4.171; and Emergency response and planning, 4.126. t-test indicated that there was no significant difference in perception between males and females, and the perception of technical and non-technical employees with $p > 0.05$. R & C contingency table was used to evaluate the relationship between safety performance and safety compliance. The result showed that there was a significant difference between safety compliance and safety performance since $X^2_{\text{calc}} < X^2_{\text{tab}}$. Therefore, safety management system will continuously improve safety

performance. Hence, the effectiveness of safety management system cannot be overemphasized. The practice of health and safety has evolved over time, as a matter of common sense in several industries. However, this study opines that the implementation of safety management system requirements is instrumental to a sustainable continuous improvement in safety performance. The study, therefore, encourages organisation to consider the safety management system certification.

Keywords

Audit, Safety Performance, Safety Compliance, Perception, Safety Management System

1. Introduction

According to Sweeny: “Health and safety management systems emerged as a key prevention strategy in the mid-1980s. The Bhopal disaster is credited as the catalyst for attention to management systems in the process industries” [1], although the concept of a systems approach had been evident since the 1960s [2], over 2000 persons died and several thousand were injured in 1984 by the leaking methyl isocyanate that happened at Bhopal. Kletz in his work concluded that the issues identified as contributing to the disaster were inadequate attention to the design of the gas plant and process, maintenance and testing of plant and protective equipment, training and emergency planning, as well as the failure to implement recommendations and lack of attention to the broader planning issues associated with plant layout in residential areas [3].

Podgorski stated the occurrence of the alarming incidents data clearly emphasizes the need for effective occupational safety and health management system that integrates safety and health concerns into a daily routine [4].

According to Granerud and Rochas: “Safety management systems are systematic instruments and powerful tools that enable different organizations to manage their occupational health and safety risks, and also help top management to contain related health and safety issues in the industry” [5].

Energy Safety Canada (ESC) defined safety management system (SMS) as a systematic approach put in place by an employer to minimize the risk of injury and illness. It involves identifying, assessing, and controlling risks to workers in all workplace operations. An effective SMS is a key component of any business; its scope and complexity will vary according to the type of workplace and the nature of its operations [6].

The most important roles of the safety management system in any organisation are to support and promote safe practices and identify key legal, moral and economic issues relating to occupational health and safety management. According to Ramli *et al.*; “Most new research into Occupational safety and health has been restricted to specific topics such as the certification process, the benefits

of SMS implementation, the impact on company performance and employees' attitudes toward unsafe acts, and its effects on the occupational accident rate" [7].

The most reputable occupational health and safety management systems, which are increasingly popular in the oil and gas industry include the Occupational Health and Safety Assessment Series (OHSAS 18001), Occupational Health and Safety Management—requirements of International Standard Organisation (ISO 45001), the Occupational Safety and Health Administration's Voluntary Protection Program, and International Labor Organization guidelines (ILO-OHS 2001) [8].

Despite major advances in occupational health and safety (OHS), which have led to measures that aim to prevent injuries and illness in the working environment, challenges persist in many organizations [9]. Risks endanger the workforce, equipment, working environment, and impact the competitiveness and economic performance of both industries and communities. Occupational accidents and diseases have profound adverse consequences: workers are injured; equipment is destroyed; the quantity and quality of production fall. There are economic losses due to early retirement and staff absence, all of which adversely affect the organization's reputation and competitiveness [10]. According to statistics, such incidents result in nearly 2.3 million deaths every year and incur costs of over 2.8 trillion dollars globally [11]. These findings clearly show that occupational accidents and diseases are a major concern and must be properly managed.

Aside from processing safety-related hazards, the industry is exposed to health and safety risks associated with activities like scaffolding, rigging and lifting, manual handling operations, machining, painting and several occupational diseases as a result of exposure to various hazards in the workplace.

This study focused on determining the effectiveness of safety management system implementation through the assessment of compliance to safety management system requirements (SMS) with elements including, the general requirements of the SMS, health and safety policy, planning, implementation and operation, audit and management review; and identification of employee perception on the implication of SMS, as well as, evaluation of safety compliance to the requirements in relation to performance in a selected liquefied natural gas (LNG) company. Other secondary sources of data included the health and safety reports that were reviewed.

2. Material and Methods

2.1. Sample Size and Population

A safety management system certified liquefied natural gas company was carefully identified and selected for this research work. A population size of 100 members of staff of the identified liquefied natural gas company were selected randomly for this study for the administration and completion of the question-

naires collating the perception of the workers to implication of safety management system in the organisation. The questionnaires were administered randomly to 100 workers categorized as technical and non-technical workers and gender; male and female.

2.2. Method of Data Collection

The method adopted for carrying out this work is the use of questionnaire and checklist for primary data collection. The questionnaire consists of open-close ended questions which was self-administered. The questions are answered with a 5-point Likert scale, ranging from strongly disagree to strongly agree.

The checklist also containing 85 questions, grouped into the elements of the safety management system, was used to check the company's compliance to the relevant safety management system requirements through inspections, review of documents, and interview where necessary. Such information from documents and health and safety reports of the organisation formed the secondary data.

2.2.1. Compliance to Safety Management System Requirements Checklist

The safety management system checklist that was used contains 85 questions which were carefully answered by inspecting the risk areas, checking documents, and interviewing personnel where necessary. The checklist was adopted from OHSAS 18001:2007 internal audit checklist. The 85 questions are distributed through 6 parts of the checklist. These 6 parts represent the core elements of the safety management system. The parts include; General requirements, health and safety policy, planning, implementation and operation, checking or auditing, and management reviews.

The guideline part of the checklist specifies the necessary principles and methodology for carrying out an effective audit and also, the scoring criteria.

2.2.2. Workers' Perception to the Implication of SMS Questionnaire

The questionnaire used consists of 35 open-close ended questions adapted from Safety Climate Assessment Questionnaire, developed by Flin, Mearns and Burns [12] from University of Aberdeen. It is divided into two sections: A and B. Section A includes demographic information such as age, department, length of years in service, and gender. Section B consists of 35 questions which are used to identify the perception or opinion of workers or employees on the company's health and safety management system. Section B is further divided into 7 sections which focuses on specific area of general safety climate in the industry, they include: safety satisfaction and feedback, training and competence, safety reporting and investigation, work pressure, management commitment, safety communication, and emergency preparedness and response.

2.3. Method of Data Analysis

The data collected from the checklist and survey was compiled and assigned codes. The coding made data representation and analysis convenient. The data

was then analyzed using the Statistical Package for the Social Scientists (SPSS) version 25. Descriptive methods were used to simplify and characterize the data. Further statistical analysis includes t-test, Row and Column Contingency Table. Significance was set at a two-tail with an alpha level of 0.05.

3. Results and Discussions

3.1. Determination of Compliance Level to Safety Management System Requirements

Based on the findings at **Figure 1**, it showed that the level of compliance to the requirements of the safety management system was high, ranging between 91% - 98%. From the chart, it showed that the company has 91% compliance to the general requirements, 95% to Health and Safety Policy, 93% to Planning, 98% to Implementation and Operation, 98% to Audit or Checking, and 93% to Management Review. The overall average compliance of the organization as shown in the graph was 95%.

According to Hasse *et al.*: “an excellent compliance to the implementation of the SMS requirements in any organization generally translates to effective management of risk, improving the leading indicators like training, management visit, inspections, maintenance, action items, investigations, audit, safety meeting, near-miss reporting, and risk assessment” [13].

The general requirements of the SMS include setting up the management system itself and how the requirements are to be fulfilled [14].

3.2. Demographic Information of Respondents

Figure 2 below revealed demographics information of the survey respondents where 6.4% were male and 36% female. About 28% have worked between 16 to 20 years and 27% between 11 to 15 years. There were about 68% technical and 32% nontechnical personnel comprising of 36% of majority between the age group 31 - 40 years and 28% between 41 - 50 years.

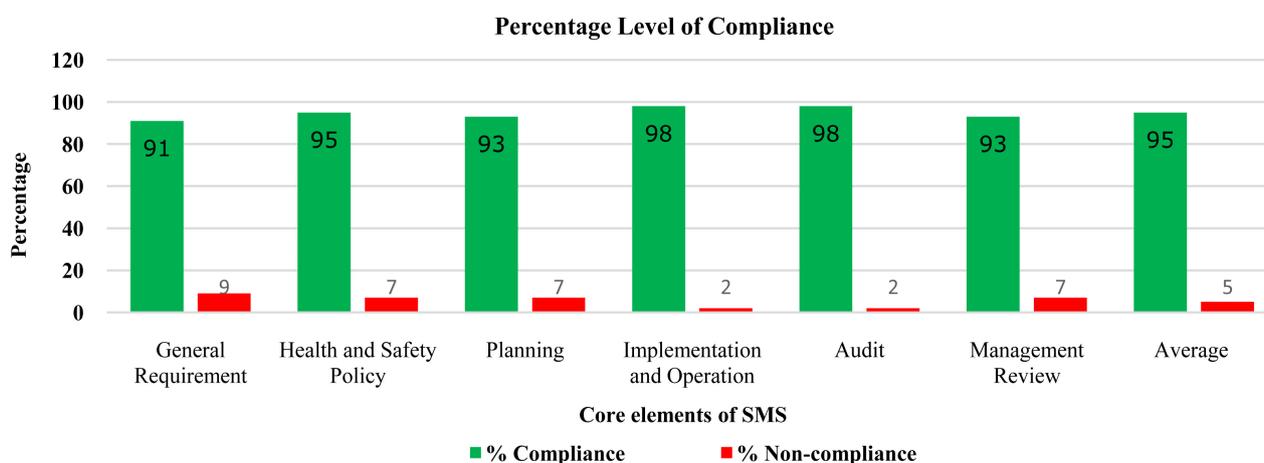


Figure 1. Showing the level of safety management system compliance.

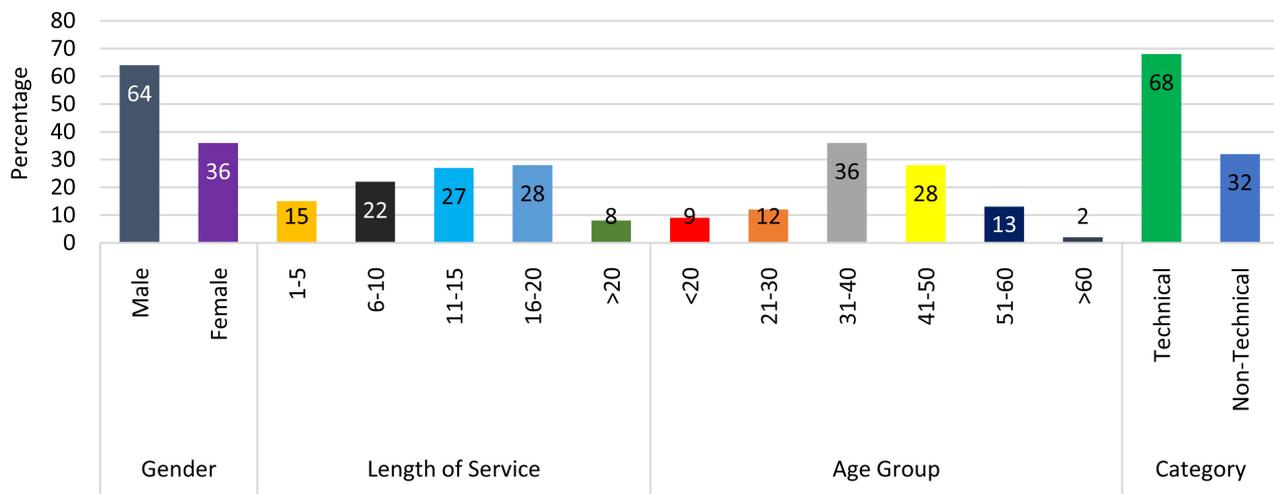


Figure 2. Showing distribution of respondents to the questionnaire.

3.3. Determination of Employee’s Perception on the Implication of Safety Management System

The priorities of employee’s perception on occupational health and safety management in the organization are presented at Figure 3. Descriptive statistics were used to measure the elements of occupational health and safety management that is assumed to be the most important to the employees. Among the elements, safety reporting and investigation element was perceived very high with mean of 4.212 and standard deviation of 0.56950 while work pressure element was perceived as slightly low with mean score of 3.989 and standard deviation of 0.62893. As indicated by the results, employees’ perception on occupational health and safety practices were between the ranges of 3.989 to 4.212, thus indicating a slight mixture of “Disagree” to “Strongly Agree”. The results indicated that the general view of the employees with regard to their occupational health and safety practices were significantly high.

Findings of previous studies done by Podgorski showed a relationship between employee optimism and good safety performance [4]. When management of any organisation blames the workers for injury and incidents, OHS performance is lower and vice versa [15]. For that reason, organizational culture is vital in determining that employees and employers have a high priority to implementing best practice in health and safety.

3.4. Differences between Genders

Test of Hypothesis for t-Test Analysis

H_0 : There is no significant difference between the opinion of male and female employees on the areas of safety climate;

H_a : There is significant difference between the opinion of male and female employees on the areas of safety climate.

Based on the research findings at Table 1, t-test analysis was used to access the statistical significance of the differences between male and female employee’s

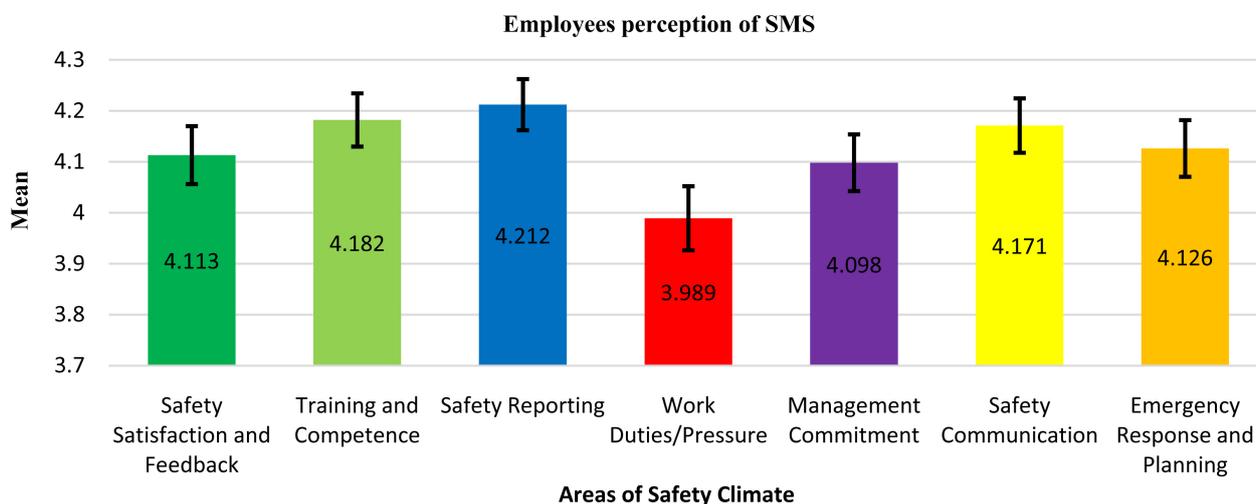


Figure 3. Showing priorities of employee's perception on OHS management.

Table 1. t-test analysis for genders.

Safety Variables	Levene test for equality of variances	t	Sig (2-tailed)
Safety Satisfaction and Feedback	0.004	-1.349	0.179
Training and Competence	0.001	-1.376	0.071
Safety Reporting and investigation	0.001	0.038	0.044
Work Duties/Pressure	0.059	0.315	0.753
Management Commitment	0.032	0.088	0.114
Safety Communication	0.001	-1.010	0.587
Emergency Response and Planning	0.174	-0.485	0.700

perception on the areas of safety climate in the organisation. Empirical evidence showed that there were no significant differences for the areas of safety climate between the two genders, except for safety reporting and investigation, where $t = -1.349$; $p > 0.05$ (safety satisfaction and feedback), $t = -1.376$; $p > 0.05$ (training and competence), $t = 0.315$; $p > 0.05$ (Work pressure), $t = -1.010$; $p > 0.05$ (safety communication), $t = -0.485$; $p > 0.05$ (emergency preparedness and response), and $t = 0.088$; $p > 0.05$ (management commitment). Thus, null hypothesis was accepted. The results suggested that the two gender groups interpret the variables in the same way. Nevertheless, the results revealed significant differences between male ($M = 4.1182$) and female ($M = 3.9924$) workers on safety reporting and investigation, where $t = 0.038$; $p < 0.05$, thus, alternative hypothesis was accepted. It was seen that male workers perceived significantly stronger safety reporting than female workers.

According to the findings disclosed by Yule *et al.*: "health and safety issues affect both men and women at work" [16].

3.5. Differences between the Categories of Workers (Technical and Non-Technical)

Test of Hypothesis for t-Test Analysis

H_0 : There is no significant difference between the opinion of technical and non-technical employees on the areas of safety climate;

H_a : There is significant difference between the opinion of technical and non-technical employees on the areas of safety climate.

From the research findings at **Table 2**, t-test analysis was also used to access the statistical significance of the differences between technical and nontechnical employee's opinion on the areas of safety climate. Evidence from the test results indicated no significant differences were found for the safety variables between the two categories of workers, where $t = -0.146$; $p > 0.05$ (safety reporting and investigation), $t = -0.949$; $p > 0.05$ (safety satisfaction and feedback), $t = -0.180$; $p > 0.05$ (training and competence), $t = -0.515$; $p > 0.05$ (Work pressure), $t = 0.720$; $p > 0.05$ (safety communication), $t = -0.492$; $p > 0.05$ (emergency preparedness and response), and $t = 0.231$; $p > 0.05$ (management commitment). Thus, null hypothesis was accepted. The results suggested that the two categories of workers interpret the variables in the same way.

This test revealed that health and safety issues affect all people at work. According to National Oil-heat Research Alliance-NORA [17]: "occupational accidents and ill-health are avoidable and cooperation among all people with a positive commitment will ensure this mission to be achieved." However, individual accountability is the main factor in safety mission where it must be expanded to all department and starts from the management to all employees [18].

3.6. Relationship between Safety Management System Compliance and Safety Performance

From the result presented in **Table 3** below, level of compliance to safety management system was subjected to a relationship test with safety performance in the organization. This analysis was done using the Row and Colum Contingency Table at 5% level of significance.

Table 2. t-test analysis for categories of workers (technical and non-technical).

Safety Variables	Levene test for equality of variances	t	Sig (2-tailed)
Safety Satisfaction and Feedback	0.040	-0.949	0.145
Training and Competence	0.011	-0.180	0.405
Safety Reporting and Investigation	0.013	-0.146	0.066
Work Duties/Pressure	0.507	-0.515	0.054
Management Commitment	0.232	0.231	0.206
Safety Communication	0.001	0.720	0.060
Emergency Response and Planning	0.340	-0.492	0.124

Table 3. Row and column contingency table.

Safety Performance	Level of Compliance to SMS Requirements						TOTAL
	General Requirement	Health and Safety Policy	Planning	Implementation and Operation	Checking	Management Review	
Satisfactory	0.91	0.95	0.93	0.98	0.98	0.93	5.68
Unsatisfactory	0.09	0.05	0.07	0.02	0.02	0.07	0.32

Test of Hypothesis

H_0 : There is no relationship between compliance to safety management system requirements and safety performance;

H_a : There is a relationship between compliance to safety management system requirements and safety performance.

$$X_{\text{calculate}}^2 = \frac{\sum(O_i - E_i)}{E_i}$$

$$X_{\text{cal}}^2 = 0.081$$

From the Row X column contingency table

$$\alpha = 0.05$$

$$df = 5$$

$$\therefore X_{0.975,5}^2 = 2.571$$

$$X_{0.025,5}^2 = 0.831$$

Since the value of X_{cal}^2 falls outside the lower region of the distribution curve, the null hypothesis, H_0 will be rejected and the alternative, H_a accepted. It is therefore concluded that there is relationship between compliance to safety management system requirements and level of safety performance in the organization.

From the secondary data retrieved from the company's HSE report, it was discovered that the company had recorded no fatalities, 7 Lost Time Injury (LTI), 9 Medical Treatment Cases (MTC), 17 First Aid Cases (FAC), 830 Near-miss reported, 104,167 reported unsafe acts and unsafe conditions, 1052 health and safety walkabouts, 582 Safe System of Work audits, 152 Senior Management Team (SMT) site engagement, and about 48,066,469 cumulative man-hours in 20 months. From these reports, we could also infer that the high number of reported unsafe acts and conditions, SMT engagement, audits, HSE walkabout and about 48 million man-hours in relation to the number of incidents also correspond to the results of the various analysis and test of hypothesis between compliance to safety management system and safety performance.

More so, this was also in line with the work done by Lee *et al.*, on the effect of occupational health and safety management system on work-related accident rate and differences of occupational health and safety management system awareness between managers in south Korea's construction industry. They indicated that, the accident rate, among top 100 largest construction companies, is much lower for the SMS certified companies than that for the noncertified companies. The average accident rate is lowered by 67% when safety management

system certified companies were compared with noncertified construction companies. This reduction is likely due to the implementation of safety management system, because the influencing factor of the company size has been mitigated [8]. This view was also supported by Mengolini and Debarberis that: “high safety performance correlates with elements including strong safety management commitment, interaction between workers and supervisors, and open communications on safety” [19].

According to Energy Safety Canada: “many benefits are associated with the development and implementation of a safety management system. Most importantly, an effective safety management system can help prevent injuries and property loss, reduce costs, and support due diligence. Developing a proactive approach to health and safety through a health and safety management system and its essential elements results in long-term financial and cultural benefits.” [6]

4. Conclusion

This study has shown that there is a relationship between safety management system implementation and safety performance by testing for dependency between the two variables in the liquefied natural gas company. The R & C table analyses indicated that there is a significant difference between compliance with the safety management system and the company’s safety performance. The result obtained from employees’ perceptions and secondary data retrieved from the company’s HSE reports also supported these results. Therefore, it is concluded that safety management system is key to improving the safety performance of a company, and safety management system is hence, effective in the organization. There is a need for ongoing commitment and determination from all parties concerned for the improved safety performance in the organization to be sustained.

Acknowledgements

Petroleum Training Institute, Delta State, Nigeria is the only technical school established for the training of technical manpower for Nigeria’s oil and gas sector. We would like to acknowledge the Head of Department of the Industrial Safety and Environmental Technology, graduate students and other administrators that made this work a success.

Conflicts of Interest

The authors declare no conflict of interest regarding the publication of this paper.

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