

The Relationship of Organization Failure Modes and Effects Analysis with the Safety Quality for Supply Chain Risk Management

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Abstract- Supply chain risk management (SCRM) is a key component of not only supply success but firm success as well. All Companies aim to achieve the highest level in quantity and quality of their products in the shortest time while preserving the safety of their workers and providing all appropriate conditions for them. Whereas many institutions spend a lot of money to implement international safety and quality standards in order to reach this goal, they continue to suffer from some failures on the level of worker safety and unstable product quality. The presence of the human factor necessarily means the possibility of errors, and these errors naturally have accumulations that may reach even the furthest point in the organization and this leads to an increased possibility of accidents and fluctuations in product quality and waste of time. In view of the common goals and similarities between the Failure Modes and Effects Analysis (FMEA) organization, supply chain risk management, and the effective pivotal role of the FMEA organization in extracting points of failure and errors at the FMEA organization and field levels. Linking them in a way that allows managers to explore errors in the least time possible to remedy its consequences. The relationship between the FMEA organization and product quality management aims to improve performance and improve product quality in the shortest possible time.

Keywords; Safety, quality, SCRM, FMEA, management, risk, organization.

1. Introduction

Companies in various domains face internal and external work errors and failures, the state of crisis in the company can be affected by various interrelated external and internal causes, which as to intensity and appearance vary by company, and the essence of the causes surely lies in the management of the company [1]. The internal influences are defined by the company's environment; the external ones come under everyone's private life [2]. Most studies agree that though there is a reasonable reduction in

workplace injuries and fatalities across industries; significant casualties still exist in workplaces due to unsafe acts [3, 4]. The failure in the institutions is the increase in workplace accidents i.e. human losses, instability in the production capacity with a decrease in the quality of the product, thus, damaging the institution's reputation externally. In this study, we provide possible solutions for institutions to work more efficiently and consistently in the field of safety and supply chain risk management to correct errors that the institutions are exposed to with the continuous improvement of safety and quality management, through the role of the FMEA organization (Failure Modes, Effects Analysis is a method designed to identify and fully understand potential failure modes and their causes, and the effects of failure on the system or end users, for a given product or process, assess the risk associated with the identified failure modes, effects and causes, and prioritize issues for corrective action and identify and carry out corrective actions to address the most serious concerns [5]) in spotting points of failure and correcting their causes. Here we ask the main question for the study, what is the importance of using the FMEA organization in the safety management quality system? This leads us to ask other questions to show the main objective of this study. What is the relationship between the FMEA organization in developing product quality and improving the safety system? How does the FMEA organization resemble safety management? How effective is the FMEA organization at the level of supply chain risk management?

Supply chain risks can be mitigated to a great extent by the qualification and selection of the appropriate supplier. The purpose of this study was to identify how companies manage supply chain risks, with a particular focus on the use of Failure Mode Effects and Analysis (FMEA). Through the studies, we have found that the workplace accidents, the product quality failure, and the

wasted time are caused by the mismanagement, lack of experience and efficiency of the workers. In this study, we show the relationship between the FMEA organization and the quality of safety management while showing the importance of the FMEA organization not only in determining the danger, and the possibility of all failures, but also in suggesting possible solutions. In addition, we demonstrate how the FMEA organization helps officials extract points of failure at the administrative level and the practical level, which will enable institutions to avoid losses and improve the quality of safety for workers, which will eventually help workers to develop the quantity and quality of the product in a shorter time.

2. Methodology and Materials

A qualitative methodology has been used when conducting this research with a special focus on safety and quality aspects in order to determine all aspects that directly or indirectly affect the quality and supply chain risk management at work.

According to the requirements of the scientific research methodology, official information and data were collected from various sources (official documents in quality assurance, safety and health, data and statistics on the number of annual injuries and losses, work sites visits, interviews with workers when they are working, and with administration officials). The documents and field visits were intended to detect as many obstacles and failures when working as possible and at the product that arise over time during the implementation of the institution's quality and safety management system.

The FMEA organization has been used on the information that we gathered in order to extract all the failures that exist in the workplace, management and at the product level to reveal the degree of their severity and frequency, and to provide possible solutions to develop the quality of the product by creating appropriate conditions for work. We will rely on the existing relationship between safety and quality and on how to use the FMEA organization to promote this relationship.

3.1 Failure Mode and Effect Analysis (FMEA)

3.1.1 Brief history of FMEA

FMEA was formalized in 1949 by the US Armed Forces by the introduction of Mil-P 1629 Procedure for performing a failure mode effect and criticality analysis. The objective was to classify failures according to their impact on mission success and personnel/equipment safety.”[6] It was later adopted in the Apollo space program to mitigate risk due to small sample sizes. The use of FMEA gained momentum during the 1960s, with the push to put a man on the moon and return him safely

to earth [5, 6]. It consisted of drawing up a list of the components of a product and accumulating information on the failure modes, their frequency and their consequences. The method was developed by NASA and the arms industry as FMEA to assess the effectiveness of a system. [7]

They also used it to improve production and design. In the 1980s, the automotive industry began implementing FMEA by standardizing the structure and methods through the Automotive Industry Action Group. Although developed by the military, the FMEA method is now extensively used in a variety of industries including semiconductor processing, foodservice, plastics, software, aeronautics, automotive, and healthcare, to name a few. [8] The traditional FMEA is an important technique that is used to identify and eliminate known or potential failures to enhance the reliability and safety of complex systems and is intended to provide information for making risk management decisions. Each failure mode is assessed in three parameters, namely, severity (S), likelihood of occurrence (O), and difficulty of detection (D) of the failure mode. Three parameters are utilized to describe each failure mode by rating them on a numerical scale from 1 to 10 and evaluated according to ordinal scales of measure. The risk priorities of failure modes are determined through the Risk Priority Number (RPN), which is the product of the S, O, and D of a failure.

In general, the risk priorities of failure modes through the risk priority number (RPN), by calculated as a product between the probabilities of the severity (S), occurrence (O) and detection (D) of failure. That is $RPN = S \times O \times D$. [9]

The FMEA team determines, by failure mode analysis, the effect of each failure and identifies single failure points that are crucial. It may also rank each failure according to the criticality of a failure effect and its probability of occurring. [6]

Table 1. The four basic questions of FMEA

Potential failure modes	Possible effects	Possible causes	Monitoring plan
Monitoring plan	What could be the effects?	What could be the effects?	How to see it?

3.1.2 Types of FMEA

- **The FMEA Organization** applies to the different levels of the business process: from the first level which includes the management system, the information

system, the production system, the personal system, the marketing system and the finance system, up to the last level like organizing a work task.[7]

- **System FMEA** looks for potential problems and bottlenecks in larger processes, such as entire production lines
- **Design FMEA** is carried out to eliminate failures during equipment design, taking into account all types of failures during the whole life-span of the equipment
- **Process FMEA** is focused on problems stemming from how the equipment is manufactured, maintained or operated [7]
- **FMEA-security, FMEA-medium, FMEA-process, FMEA-product** [7]

3.1.3 FMEA benefits

The FMEA will: highlight single point failures requiring corrective action; aid in developing test methods and troubleshooting techniques; provide a foundation for qualitative reliability, maintainability, safety and logistics analyses; provide estimates of system critical failure rates; provide a quantitative ranking of system and/or subsystem failure modes relative to mission importance; and identify parts & systems most likely to fail.

a. Therefore, by developing a FMEA during the design phase of a facility, the overall costs will be minimized by identifying single point failures and other areas of concern prior to construction, or manufacturing. The FMEA will also provide a baseline or a tool for troubleshooting to be used for identifying corrective actions for a given failure. This information can then be used to perform various other analyses such as a Fault Tree Analysis or a Reliability-Centered Maintenance (RCM) analysis.

b. The Fault Tree Analysis is a tool used for identifying multiple point failures; more than one condition to take place in order for a particular failure to occur. This analysis is typically conducted on areas that would cripple the mission or cause a serious injury to personnel.[9, 10]

The application of the organization FMEA also has benefits in various fields:

- Contributes to improved designs for products and processes.
 - ✓ Upper reliability.
 - ✓ Better quality.
 - ✓ Enlarged safety.
 - ✓ Improved consumer satisfaction.
- Contributes to cost savings.
 - ✓ Decreases development time and re-design costs.
 - ✓ Decreases warranty costs.
 - ✓ Decreases waste, non-value added operations. (LEAN Management).

- Contributes to the development of control plans, testing requirements, optimum maintenance plans, reliability growth analysis and related activities [11].

3.1.4 The principles and relationship of quality and safety

In order to ensure the continuous development of institutions and ensure the confidence of the external consumer, the institutions must provide products that meet safety and health standards for customers on the one hand, and on the other hand, provide quality standards of safety and health for workers by creating an appropriate work environment.

The first person who talked about the existence of a relationship between quality and safety, and gave a glimpse of the great correlation between quality and safety at work through the causes and results, was Dumas, emphasized, “safety is a dimension of quality, after everything, the elimination of defects includes the elimination of practices of unsafe work” [12]. This is because the basic premise of quality management is identification and correction of variance (or unwanted outcomes) in a process. For safety, variance is in the form of workplace hazards, unsafe behavior, and accidents caused by human error [13].

Emphasized that in order to obtain great safety results, organizations need to integrate the safety system into the quality management system, where the author commented that safety and quality are basically the same thing [14].

Table 2. The comparison between principles of quality management and safety management [14]

Safety	Quality
Objective: zero accidents	Objective: zero defects
Analysis of incidents	Analysis of events
Documenting the politics of safety, the procedures and the instructions	Documenting the politics of quality, the procedures and the instructions of work
Safety committees	Quality circles
Participation of the workers	Participation of the workers
Statistical analysis	Statistical control of the process
All accidents and injuries could be prevented	The not conformities could be prevented

3. Results and discussion

In order to demonstrate the effectiveness of the organization FMEA in improving the quality of supply chain risk management and the role that the FMEA organization plays between quality and safety

management in institutions, we present some of the results of applying the administrative system that we have done to a well-known company in the world (Sonatrach: the largest petroleum company in Algeria and Africa) after we have seen enough information from the administration and workers.

Immediately and applied to management, three senses can be attributed to the word organization.

Meaning 1: the activity of organizing, which consists in particular in developing a structure, procedures, an order specific to the system.

Meaning 2: the organization is the framework that represents for its members the state of a system after the

act of organizing, in particular in terms of structures and culture.

Meaning 3: the organization is a social institution as an organized system.

The components of the organization:

- Training, awareness, skills (authorizations, clearances);
- Staff consultation;
- Documentation;
- Internal and external communication;
- Responsibilities and resources.

Table 3. The organisation

Activity (act of organizing)	Terms of reference (state after the act of organizing)	Institution (system)
Structure, organize, behave in such a way as to carry out an order. That is to say: Create rules, formalize relationships between humans, but also between humans and machines. Define values, desired behaviors, objectives. Lead staff by: - Grouping tasks - Creating units - Structuring relationships - Guiding the behavior of Contributors....	Networks of relationships and interactions, formal and informal structures and processes, which are created, consciously or not, to achieve a goal and objectives. That is to say: Relations and interactions between individuals, information, machines, ... Cultural elements specific to each system, concrete or symbolic. A set of instruments: - Organizational chart - Function diagram - Flow diagram - Company charter - Value system...	Sociotechnical system composed of individuals, technical means, materials gathered together for a goal, and objectives. That is to say: A system born formally or informally. A system composed of actors playing different roles, fulfilling various activities. An institution: - Business - Hospital - Administrative department - Political party - Non-governmental organization

The FMEA organization method is a technical method, and its application depends on specific techniques and special methods to extract the information because the management system contains branches such as formation, communication, and documentation. To apply the FMEA organization well and achieve the desired results, it requires an in-depth technical study, the use of data and information extracted in applying the administrative system, in Table 4 we found some of the failures that we

extracted from the information collected from the files and data (official documents, statistics, surveys and field dialogue with workers). Where we find that most failures are the real causes of management, this is due to the absence of a periodic management strategy that allows it to discover failures in the organization. This leads to the multiplication and persistence of failures, and consequently the continuing occurrence of human and material losses at the field level.

Table 4. Representation example of the modes of failure in the organization of the company

Formation	Internal and External Communication	Staff consultation
Poor training on occupational diseases; Lack of qualitative and quantitative training for staff.	Lack of good communication between workers and management Bad atmosphere in the group; Contact problem during work due to noise.	A quality problem in Management; Poor consultation; with group delegates .

The FMEA organization is directly applied at the enterprise management level in all aspects of management, where the organization FMEA works to extract weaknesses in management and work problems at the level of safety, health and even quality, in order to correct errors, evaluate them, and then provide possible solutions to achieve quality in safety and management. The most adopted quality principles by the surveyed firms

were respectively: continual improvement, customer focus, process approach, factual approach to decision-making, system approach to management, and involvement of people. The actual application of the FMEA organization and its results by addressing the failure points in Table 06 and other failure points you can find in Table 06.

Table 5. Organizational FMEA table for company organization

Organisation opération		Potential failure mode	Effect of failure	Possible cause of failure	Evaluation			Preventive actions	Resulting		
					O	D	G		Recommended		
Organization	Formation	- Poor training on occupational diseases	- Occupational diseases - Work accidents - Work stoppage	Lack of recurrent training sessions	4	4	5	Good training on occupational diseases and accidents at work (examples, practices, ...)	2	2	3
				Training does not have the practical side	3	1	4	Scientific outings and applications in the field	1	1	2
				Neglect among staff	4	3	4	Make the personal spirit of security	2	1	2
	Lack of qualitative and quantitative training for staff.		- Old equipment broken down, - Poor maintenance - A reduction in production. - Work accidents. - A large number of breakdowns.	The absence of a culture based on maintenance training	5	3	5	Provide qualitative and quantitative training for staff.	3	2	3
				Bad skill.	3	1	3	Improving staff skills	1	1	2
				Delay in execution by management	4	5	4	Facilitate procedures for carrying out maintenance, renovations,	2	2	2

3.1 The relationship of FMEA organization with the quality of safety management

The FMEA-organization applies to the different levels of the business process: from the first level which includes the management system, the information system, the production system, the personal system, the marketing system and the finance system, up to 'last level like organizing a work task.

Professional mistakes in management and direction, and in the way of communication between management, and the failure of the correct information to reach its appropriate place and time,

It results in other mistakes in different areas of the institution, the impact of this mistakes may be material or human, so when we talk about the human side, workers are exposed to many risks and injuries during work due to lack of training or poor contact with the managers,

As for the material side, the lack of quality of the product and the image of the institution is damaged externally, thus weak profit and incomes, so the organization FMEA reveals points of failure in the various

parts of the organization and all possible causes, especially administrative mistakes, which allows officials to correct errors and remedy human or material losses that harm the institution internally and externally, because as all safety professionals know, remediation is by correcting the first cause of the error.

Safety professionals from companies adhering to the traditional method of safety direct and control workers so that they complete the expected company safety standards and regulations.

They also enforce laws and government regulations. They are informed on new regulations, devoted to impose rules and regulations to their employees, carry out inspections, audit the system, direct investigations of accidents and injuries, and establish recommendations in order to prevent accidents and injuries in the future. For the safety professionals, adhering to this concept means modifying the behavior of the worker, motivating them, and using prizes and incentives to help them work in a safer way. Rewards are given only to those workers or departments that meet the preset safety objectives [12]

when safety management is based on the results of accidents and injuries, the efforts of safety are stimulated as a function of accident and injury statements, and one can tell top management about the need to pay more attention to the prevention of accidents at times when the rates of accidents and injuries increase. This will also diminish having to pay attention when injuries rates are lower. [15-20]

We, through the study, concluded that most accidents are due to management errors from the institution. The lack of communication and poor training for workers and incomprehensible decisions by the managers cause a dire outcome, both at the human and material level.

Through the study, we conclude that the institutions seek to achieve their underlined goals in an appropriate time with a lower material and human losses, but it is natural that obstacles and errors arise in the middle of the work that result various points of failure. Here the role of the organization FMEA enters to overcome these obstacles, to avoid errors, and to provide possible solutions, herein the relationship appears between the organization FMEA and the safety quality management system in the common goals, and the role that the organization FMEA presents to achieve the goals of the safety quality system in the best possible way.

Table 5. FMEA Quality Objectives [16]

DESIGN IMPROVEMENTS	The FMEA drives product design or process improvements as the primary objective.
HIGH RISK FAILURE MODES	The FMEA addresses all high-risk failure modes with effective and executable action plans.
DVP/CONTROL PLAN	The Design Verification Plan (DVP) or the Process Control Plan (PCP) considers the failure modes from the FMEA.
INTERFACES The FMEA	Scope includes integration and interface failure modes in both block diagram and analysis.
LESSONS LEARNED	The FMEA considers all major "lessons learned" (such as high warranty, campaigns, etc.) as input to failure mode identification.
LEVEL OF DETAIL	The FMEA provides the correct level of detail in order to get to root causes and effective actions.
TIMING The FMEA	Is completed during the "window of opportunity" whence it can most effectively influence the product or process design.
TEAM	The right people are adequately trained in the procedure and participate on the FMEA team throughout the analysis.
DOCUMENTATION The FMEA	Document is completely filled out "by the book" including Action Taken" and final risk assessment.
TIME USAGE	Time spent by the FMEA team is an effective and efficient use of time with a value added result.

3.2 The similarities between organization FMEA and quality of safety management

The big relationship between safety and quality, whether related causes and results or goals, where in order to provide safety and health in the workplace and to provide a product of quality and safety to the consumer, it requires correcting a lot of errors at the management level and reducing accidents in the workplace, and this particular role is played by the organization FMEA. Where it works to correct and improve the lines of linkage between management and the workplace at the internal level of the institution and at the external level, where through the study we conclude that the aspects of the relationship between the organization FMEA and the quality of safety management lie in the common goals that can be summarized as follows:

- Customer satisfaction is the major objective of FMEA, an objective against which no one can rise today. If there was only this single argument in favor of FMEA, it should be enough to make it essential in our organizations. [21]

- Managing continuous improvement by managing action plans.

- The development and management of these plans will, with regular updates from FMEA, be one of the major means of bringing continuous improvement to life and demonstrating its implementation. [22]

- Improved communication. Although rarely cited as an advantage of FMEA, it is one of the major advantages for us. It is indeed a question of placing around a table colleagues from different departments in order to make them work in a group, using the same logic and the same vocabulary to exchange information which will necessarily be useful to them for the rest of their work.

- Improving the stability of products, processes, services, machines, etc. It is a priority to act on things that hinder, destabilize, complicate ... You will use FMEA to make it more stable, better controlled, better known, better understood, less dangerous..., what you are working on.

- Cost reduction. Contrary to what some claim, FMEA helps you to reduce the internal costs of obtaining quality, provided that you also work on the internal effects (in the context of the FMEA process, on the reduction of waste and retouching).

- Optimization of controls, tests, trials, and not strengthening of these same controls. FMEA helps you to do checks only on the points that require it.

- Elimination of the causes of failures. This is one of the major objectives of FMEA which will result in the implementation of preventive measures, and even in the development of action plans.

- Written experience. Based on the FMEA reasoning, certain organizations will be brought to pass from an oral culture to a written culture. [23]

4. Discussion

Previous studies showed that the FMEA [24-28] its importance, and how it can be applied in general, but the FMEA has many types and each type has specific characteristics that are distinguished by its own field, while we demonstrate in our study that the FMEA organization specifically and in particular, where the FMEA organization is one of the important and effective types of the FMEA , And we presented all its aspects by showing its importance and benefits to the institutions while giving realistic examples of how it is applied,

Several studies emphasize the direct relationship between quality and safety in institutions in different fields [20, 28] and the need to apply international quality and safety standards, but despite the application of safety and quality standards, failures are present, while in our study we also presented the strong relationship between the quality system and the safety system, and how each of them affects on the other, with the use of the FMEA organization to protect and improve this relationship in order to protect institutions from failures and to create appropriate conditions for the institution for providing the best performance and achieve worker safety and product quality.

We used the FMEA organization to develop the relationship between the safety system and the quality system because the similarity of the real goals between the FMEA organization and the quality of the safety system, and we also presented in our study that the organization FMEA has goals in quality and goals in safety, as the characteristics of the FMEA organization allow for the approximate distance between management and the field which gives preference to remedy failures as quickly as possible and avoid possible damages in the future.

5. Conclusion

This paper aims to give effective solutions aimed at developing the supply chain risk management system and improving product quality in institutions through the use of the FMEA. Organization. The study reveals that there is a strong relationship between the safety system and the quality system, as one affects the other. Most failures are shown in the decrease in performance over time, the quality of the product decreases with the increase in the number of field accidents. The study also reveals the effective role of the organization FMEA in achieving the goals of the quality system and the supply chain risk management system together, as the use of the FMEA organization allows the extraction of the real causes of

failures at all levels and links between the management of the institution and work sites, which facilitates the detection of errors and the possibility of correcting them in the least time. As the system works, the administration is responsible for developing performance, increasing the amount of production while improving the quality of the product in the shortest possible time. Thus, the relationship between the FMEA organization and the management of safety quality appears, as it is not sufficient to only apply safety and quality standards at the enterprise level to reach advanced stages in the results, because unforeseen errors will always be present as long as the human factor is present. In addition to applying the quality and safety system standards, we suggest an FMEA organization technology that is in line with the supply chain risk management quality management system to reach the maximum in the tool and production.

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