RISK MANAGEMENT APPLYING FMEA-STEG CASE STUDY

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Abstract: Everyday, companies are submissive to several risks that may influence the good sequences of their activities. Therefore, risk management to be proved as a good management philosophy that can reduce or limits negative effects of risks. In this paper, we will focus on the Failure Mode and Effects Analysis (FMEA) as an efficient method of risk management in the Tunisian Company of Electricity and Gas (STEG), exactly in the base of electricity transmission district Gremda. After my discussions with the safety manager, the leaders and the executives in this district, we estimate that this method allows to put the risks that may affect the performance of this company and to structure these risks according to their Risk Priority Number. This step is crucial in the risk management process. This research will be useful as an audit for the safety standardization system of this company.

Key words: risk, risk management, FMEA.

Introduction

Risk management has become among the most discussed themes area in the last decade. This situation is due to the increased risks in the companies environment because the domination of uncertainty. These risks have a negative effects on the sequence of process and on the continuance of companies, we can referred to Ennouri et al. (2013) that gives some examples about the negative effects of risk on the world-famous business and on the Japanese industry. This reality can't escape from the managerial of STEG that looking for implement an efficient method to assess risks that can exist during their activities in order to set up corrective actions that reduce the occurrence of risks and in order to set up a safety management system. The first step in the risk management process is the identification and the assessment of risks, this topic has took a lot of attention by the researchers, indeed, we find several papers on this topic, for example if we take the case of "ScienceDirect (sciencedirect.com)", we find 603,507 results found related to risk identification and 1055971 results found about risk assessment. This important mass of publications proves the importance of the risk management and has an effect on the diversification of methods proposed. Among the methods used in the step of identification and assessment of risk we find the Failure Mode and Effects Analysis (FMEA), this method is considered as a most widely used in the various industries (Cândea et al., 2014). So, we proposed FMEA as efficient method to assess the risks in the base of electricity transmission of STEG, but before, we try to clarify the meaning of risk and risk management.

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Risk and risk management: short literature review

Before treating our problem relating to the risk management in the base of electricity transmission of STEG, we think it's necessary to review the concepts of risk and risk management in order to understand our context.

The risk

We think that the first step to manage risk is the understanding of the meaning of risk because this concept is very similar to other concept as the unforeseen, the vulnerability, the accident, the disturbance, which may lead to the error of method will be use and the error at the identification of risk that can cause the failure of risk management, indeed, for Karimi Azari et al. (2011) an unidentified risk can't be controlled. In the literature there are several definitions of risk because the meaning of risk depending the context and the vision of the managerial leaders. In this section, we will interest in some of the most known definitions. Aven (2012) interested at the evolution of risk definitions since 1679, he proved that this evolution depending on the evolution of time and environment. The first idea that comes to the mind is that the risk, always, is coupled with the uncertainty which puts in evidence the notion of probability, for this reason Yang (2011) given the definition of risk, inspired by Hutchins (2003), as a probability that an event or negative action affects any company. In the same direction, Tuncel and Alpan (2010) considered risk as an event probable or situations which have negative effects on the achievement of objectives. Some authors such as Taillandier (2009) and Lebraty (1967) considered the risk as a confrontation between unforeseen and stakes. For his part Ennouri (2013), referred to Mazouni (2008), the risk is an internal characteristic of decision and it's estimated by several criteria as the seriousness, the occurrence, the exposure to, the avoidance opportunities, etc. If we refer to the international standards, we find that the British Standard Occupational Health and Safety Assessment Series (OHSAS 18001) defined the risk as a result of the probability and the severity of the dangerous events. If we focus on Aven's paper (Aven, 2012), considered among one of the best papers relating to the basics of risks, we find that he gives several definitions of the risk such as "*the risk is equal the expected loss or disutility*", or "*the risk is a probability of an undesirable event*", or "*the risk is the combination of probability and extent of consequences*". For Marhavilas and Koulouriotis (2012) the risk is an undesirable event that has a dangerous consequence on the business process. Before we concluding with the risk, it should be noted that the view towards risk vary from one person to another, indeed the technological perspective view is defended by the engineers and designers, on the other hand the economic and financial view is defended by the lenders and developers. These views can be an objective or subjective view (Ennouri et al. 2014, Karimi Azari et al. 2011). If we refer to Ennouri et al. (2013), we find that the risks can divided on eleven categories which are strategic risks, operations risks, supply risks, customer risks, asset risks, competitive risks,

reputation risks, financial risks, fiscal risks, regulatory risks and legal risks. These risks must be identified and bringing under control, for this reason we must understand the notion of risk management.

The risk management

The risk management is a new research area, for this reason there isn't compromise definition to this subject, but this doesn't denies the existence of some points in common. The basic definition is given by Alhawari et al. (2012), they considered the risk management as strategies, methods and supporting tools to identify and control risk to an acceptable level, we considered the acceptable level has a fuzzy characteristic between managers. The main of risk management is the existence of managerial process, in this way; Cheng et al. (2012) considered the risk management as a process that lead to actions implementation to reduce the consequences or the probability of occurrence of negative event. The international standard of ISO 31000:2009 (ISO: International Organization for Standardization) defined the risk management as a coordinated set of activities and methods to lead to control risks can affect the achievement of objectives. According to the ISO 9001:2008, risk management is a regular continuous process allowing the identification, assess and control risks and risks situations that have caused or could cause damage to a person or property. Based on these definitions we can simplify the risk management by two basic knowledge which are the identification of risks and manage these risks through a coordination process. If we refer to Ennouri et al. (2014, 2013), Ennouri (2013), Giamakis and Louis (2011) and Tuncel and Alpan (2010), we find that the risk management is executed in four steps:

- The first step is the risk identification: allows the detection of risky events,
- The second step is the risk assessment: calculates the probability of occurrence of risks and classify risks based on these probability,
- The third step is the risk management: choice and setting up the corrective strategy,
- The fourth step is the risk monitoring: supervised the efficiency of corrective strategy and detecting the possible other risks.

These steps can be represented by the Figure 1.

We can conclude that the process of risk management resemble to Deming wheel Plan-Do-Check-Act:

- Plan: risk identification,
- Do: make managers conscious of the risks via the probability of occurrence and the corrective strategies to mitigate the risks, this is the risk assessment,
- Check: implementation of corrective strategies and supervised the result of these strategies (risk management),
- Act: supervise the efficiency of corrective strategies and adjust the list of risks in light of the circumstances and improve the process of risk management, this is the risk monitoring.

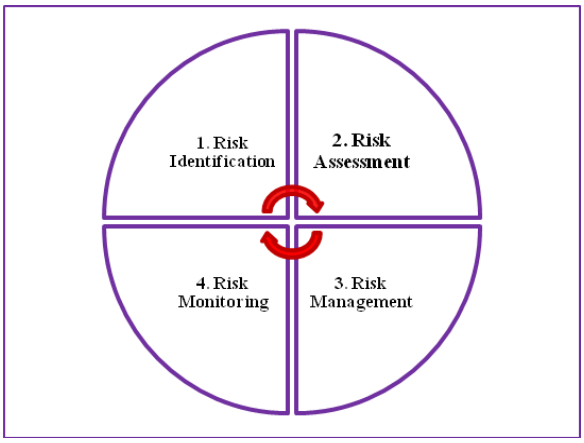

Figure 1. Risk management process

To conclude with the risk management, we think seeing that the economic activities becomes more and more complicated and involves many partners, which makes impossible the risk management only inside of the company, the concept of risk management has developed to Supply Chain Risk Management (SCRM) and the first definition of this concept was given by Juttner in 2005 (Lavaster et al., 2012). Indeed, the SCRM "*is the identification and management of risk for the supply chain, through a coordinate approach amongst supply chain members, to reduce supply chain vulnerability as a whole*" (Juttner, 2005). There are several papers about the SCRM such as Junttner (2005), Tuncel and Alpan (2010), Giamakis and Louis (2011), Lavaster et al. (2012), Ennouri (2013), Ennouri et al. (2013) and Ennouri et al. (2014).

The approaches of risk management

Generally, the approach of risk management is most imposed by the method of risk management. On the one hand we talk about *inductive* or *deductive* approach if we try to attempt to detect the reasons of the risks {Fault Tree Method (FT), Safe-Tree Method (ST)} or to attempt to detect the consequences of the risks {Hazard and Operability (HAZOP), Failure Mode and Effects Analysis (FMEA)} respectively. On the other hand, we talk about the *determinist approach* or *stochastic approach* if we use a quantitative methods {Risk measures of societal risk, The proportional risk-assessment (PRAT), The decision matrix risk-assessment, Quantitative assessment of domino scenarios (QADS), Quantitative Risk Assessment (QRA)}, qualitative methods {Check-lists, What-if Analysis, Task Analysis, HAZOP}, hybrid methods {Human Error Analysis Techniques (HEAT), Risk-based Maintenance (RBM), FT, ST} or stochastic methods that involves the probability theory {Probability Distributions, Event Data-Model, Bayesian networks, Neural networks}. There are other methods for risk management, you can see {Ennouri et al. (2014), Marhavilas and Koulouriotis (2012), Tang (2006)} for more details. The

methods of risk management share the idea of risks identification and classify of risks based on a well-defined criterion. The classification of risks is very important because for the decision-makers there are negligible risks, acceptable risks, undesirable risks and unacceptable risks and to manage them the decision-maker must choose the appropriate method according to its context. Based on the literature review, we find several application of risk management for example Hu et al. (2013) used the Bayesian network for risk analysis of High Tech project. Ma et al. (2013) used the QRA to quantify risks in gas pipeline in china. The FMEA is used in various areas for example Liu et al. (2013), Ennouri et al. (2013), Cicek and Celik (2013), CanKutlu and Ekmekcioglu (2012) and Liu et al. (2012) and has proven its effectiveness in risk management, it's easy to use and doesn't require a big budget or specific software.

Case study

The aim of our paper is the identification and assessment the potential risks in the base of electricity transmission of STEG and propose a safety measures to mitigate or reduce the probability of occurrence of these risks.

Method

The organization chart of the base of electricity transmission has given by the Figure 2.

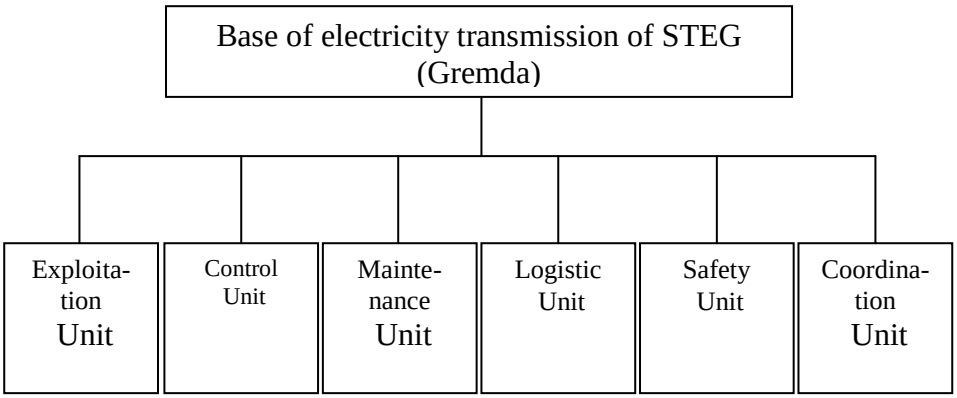

Figure 2. Organization chart of Base of electricity transmission (Gremda)

The area of this base is divided into five parts:

- Vehicle park,
- Storage area: composed of Z_1 for gas, Z_2 for fuel oil, Z_3 for fat matter and the Z_4 for tools,
- Transformer,
- Waste storage area,
- Area for departures of distribution lines and electricity network.

The first step in our research is the identification of potential risks in this base, for this reason we used the brainstorming with the safety manager, the leaders and the executives. This phase discovered 16 risks which are shared out into five classes. The second step is the assessment of these risks, we chose the FMEA method, we think that the FMEA is effective at this stage and it's appropriate for this base. Firstly, we have built the table of FMEA from the list of risks determined in the first step (table 1). Secondly, once the risks are identified and listed in this table, we listed for each risk its possible causes and its potential effects. Thirdly, based on the scale given by Liu et al. (2013) and Ennouri et al (2013); we attached a severity value (S) for each risk. After that, for each risk we attributed an occurrence value (O) based on the scale given by Liu et al. (2013) and Ennouri et al (2013). Before we calculate the Risk Priority Number (RPN) for each risk ($RNP_i = S_i*O_i*D_i$), we attributed a value for detection (D) based on the present detection controls in the base. Usually, the scales used for S, O, and D are graduated from 1 to 10. The RPN is a numeric assessment of risks, used to classify these risks according to this value.

Results

The result of our investigation is given by the Table 1, the first column presented the entity of the risks group in this base, the second presented the potential risk in this group, and the third column presented the possible causes of each risk. The fourth column devoted to the potential effects of each risk. After we calculated the RPN, we proposed in the final column some solutions to mitigate each risk. The FEMA table is very important for the safety manager, because it's revealed many gaps in the process of implementation of standard BS OHSAS 18001, this situation can disrupt their certification with this standard, and we think that our research is considered as an audit of this company.

Discussion

After that we established the FMEA table, the safety manager had chosen to classify all these risks into four categories:

- Unacceptable risk: when the RPN higher than 150 (Red color) seven risks such as human error, industrial accident, electrocution,
- If the RPN between 81 and 150 the risks are justified undesirable risks (Orange color), there are five risks judged as undesirable such as voltage drop, fire in storage area,
- Acceptable risks if the RPN between 30 and 80 (Yellow color), three risks are qualified as acceptable risks by the leaders in this base (gas explosion, failure of transformer and the toxic wastes),
- If the RPN is lower than 30: the risks are justified negligible risks (Green color), only explosion in the transformer is qualify as negligible risk.

Table 1: Application of FMEA in the base

Entity	Potential failure mode (Risks)	Potential causes	Potential effects	S	O	D	RPN	Detection or current control
Vehicle park	Human error	Stress, Recklessness, Inexperience	Crash, Damage, Victims	6	8	7	**336**	Training course, Shortened time of working, Consciousness-raising
	Technical problems	Maintenance, Old park vehicles	Lateness of intervention, Overspend	7	7	3	**147**	Daily maintenance, Change of vehicles park, Respect the amortization period
	Non-respect of the standards of loading	Lack of resources, negligence of leader	Sanction, Audit, Overspend	5	6	3	**90**	Quality control, Training course
Storage area	Gas explosion	Leak of gas, non-respect of the standards of storage, Spark, Absence of gas detector	Damage, Victims, Failure of wiring, Blackout	10	1	6	**60**	Quality control, Setting up of gas detector, Training course
	Fire	Leak of gas, non-respect of the standards of storage, Spark, Absence of fire detector	Damage, Victims, Failure of wiring, Blackout	10	2	6	**120**	Quality control, Setting up of fire detector, Training course

Entity	Potential failure mode (Risks)	Potential causes	Potential effects	S	O	D	RPN	Detection or current control
Storage area	Industrial accident	Stress, Inexperience, non-respect of the standards	Victims, Compensation	8	7	7	**392**	Motivation, Training course, Safety system
	Robbery	Absence of burglar alarm, Human error	Failure, Lack of tools, Overspend	4	4	8	**128**	Setting up of burglar alarm, monthly inventory
Transformer	Failure	Overvoltage, Failings of supply, Maintenance, Failure of operations	Blackout, Overspend	9	4	2	**72**	Daily maintenance, Safety control, Computerized the inventory
	Explosion	Overvoltage, Maintenance, Failure of operations	Victims, Blackout, Overspend, Compensation	10	1	2	**20**	Daily maintenance, Safety system
	Electrocution	Non-respect of safety standards	Victims, Compensation	9	3	6	**162**	Safety system, audit, Training courses

Entity	Potential failure mode (Risks)	Potential causes	Potential effects	S	O	D	RPN	Detection or current control
Departures of distribution lines and electricity network	Falling of electric cable	Maintenance, Non-respect of standards, weather condition	Blackout	10	4	7	**280**	Maintenance
	Voltage drop	Failure or explosion in the transformer	Blackout	10	3	3	**90**	Control system, Maintenance
	Failure in insulator	Quality of electric cable	Electrocution	8	6	4	**192**	Quality system
Waste storage area (environment)	Toxic waste	Material used	Illness, Poisoning	7	4	2	**56**	Green logistic
	Noise pollution	System state	Stress, Illness	5	9	4	**180**	Safety system, Maintenance
	Magnetic field	System state	Illness, Technical failure	5	8	4	**160**	Maintenance

We can observe that the qualification of risks based only into RPN can marginalize the effects of risks, for example the explosion in the transformer can lead to blackout, victims, compensation, and these effects make each risk as very dangerous. This is due to the detection rate and the occurrence of each risk given by the safety manager. The same idea is for the acceptable risks. For this reason, we think that the RPN is a fuzzy size that can't lead to a deterministic judgment for the risks and some negligible risks can lead to devastator effects.
We can observe the existence of some common effects between the risks, and the possible causes of risks are considered as risks in other entities. These observations prove the interaction between risks in the base of electricity transmission. This reality of interaction between risks that must exist in all case of studies about risks make the risk management more complicated. The FMEA is powerful to assess a risks by the RPN but must be completed by other methods to finish the risk management process, in this context we propose the stochastic approach seeing that the characteristic of risk is based on the uncertainty, moreover the risk cannot repeat with the same causes and don't give the same consequences.

Conclusion

In this paper, we clarified the basics notions of risk management using a full of new literature review. We had presented the risk management process as a Deming wheel, and we had presented the approaches of risk management namely inductive/detective approaches and determinist/stochastic approaches. Then, the FMEA is presented and used in the risk management in the base of electricity transmission, this method that revealed the existence of 16 risks divided into five entities in this base, these risks are qualified as unacceptable risks, undesirable risks, acceptable risks and negligible risks based on their RPN. We had observed that are several causes and consequences of these risks in common which requires the study of the interaction between these risks. This study can complete by an economic study to select the economic strategy to mitigate the risk. This paper is only a step in the process of risk management which is concentrated in the assessment of the risks.

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ZARZĄDZANIE RYZYKIEM Z ZASTOSOWANIEM FMEA - STUDIUM PRZYPADKU STEG

Streszczenie: Każdego dnia, firmy narażone są na liczne zagrożenia, które mogą wpływać na kolejność ich działań. Dlatego też, należy udowodnić, że zarządzanie ryzykiem jest dobrą filozofią zarządzania, która może zredukować lub ograniczyć negatywne skutki ryzyka. W tym artykule skupimy się na Failure Mode i Effects Analysis (FMEA) jako skutecznej metodzie zarządzania ryzykiem w Tunezyjskim przedsiębiorstwie energii elektrycznej i gazu (STEG), na bazie przesyłu energii elektrycznej w okręgu Gremda. Po rozmowach z menedżerem bezpieczeństwa, liderami i kadrą kierowniczą w tym okręgu, szacujemy, że metoda ta pozwala przedstawić zagrożenia, które mogą mieć wpływ na działanie tej spółki i uporządkować je według ich Numeru Priorytetu Ryzyka. Krok ten ma kluczowe znaczenie w procesie zarządzania ryzykiem. Badania te będą przydatne jako audyt dla systemu normalizacji bezpieczeństwa tej firmy.
Słowa kluczowe: ryzyko, zarządzanie ryzykiem, FMEA.

風險管理中的應用FMEA - STEG案例研究

摘要：每天，企業都順從，可能會影響他們的活動的好幾個序列的風險。因此，風險管理被證明是一個很好的管理理念，可以減少或限制風險的負面影響。在本文中，我們將專注於失效模式與影響分析（FMEA）作為風險管理的突尼斯公司電力和天然氣（STEG）的有效方法，正好電力傳輸區Gremda的基地。之後我與安全經理在該地區的討論，領導和管理人員，我們估計這種方法允許將可能影響該公司的業績，並根據自己的風險優先數來構建這些風險的風險。這一步是在風險管理過程至關重要。這項研究將作為該公司的安全標準化體系的審核非常有用
關鍵詞：風險，風險管理，FMEA