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Develop a safety management model using superior components of safety cost

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ABSTRACT

Identifying the components of the safety cost enables the management of safety expenditures. Safety management training through accident is not desirable.Paying attention to the safety cost, in addition to increasing productivity, reducing occupational hazards and creating a healthy environment, leads to guide and managing of safety costs in true and assigned purpose. The present study is applied research in terms of nature and purpose and based on the way of data collection is a field research. The statistical population of the study consisted of 12 safety experts who were selected by convenience sampling method and used a triangular fuzzy AHP 9-Questionnaire. The current research approach is forward-looking and 13 effective components of the cost of safety at gas refineries are extracted based on library studies. A stellar model consisting of the top 5 components of safety cost is presented. Superior safety components that comprise more than 50% of safety costs include prevention of: explosion and fire, human error, electrical and other energy hazards, high-pressure line hazards and equipment and machinery hazards. Focusing on 5 factors instead of 13 factors and smart solutions based on the detailed components of the superior factors will be the key to effective planning and management of safety cost.

Keywords:

Safety, Event, Prevention, Work Safety Success Theory, Fuzzy AHP.

1. Introduction

Accidents are an integral part of work. But this does not mean ignoring the events. Investigating safety at work and providing safe conditions in the workplace will reduce accidents, increase efficiency and productivity. On the other hand, accidents will cause losses in production. The challenge of safety cost, Due to its close relationship with human resources will be doubled. In recent years, the formation of organizational units under the heading of health, safety and environment has facilitated this process. On the other hand, in today's world, manufacturing companies are changing and evolving and focusing on central information, high flexibility, and customer satisfaction. Customers do not accept reduced safety and accidents in organizations. The study of safety factors in recent years has been post-event and often retrospective. The study of road accidents in Norway, using the principle of "minimizing as much as possible" has examined the effectiveness of applying 328 safety principles in road accidents and As a result, increase in benefits over costs and increase in driver satisfaction has been inferred (Selwick et al., 2020). Senior managers face several challenges in the safety area and accident occurrence. Therefore, the cost calculations in this case also have complexities and require the use of major factors and the elimination of minor factors. Many managers' views on the safety cost and identifying the costs of accidents are negative and avoidant. Whereas Organizations should use instructional tips to create a safe environment by investigating incidents. In the chemical and petrochemical industries, risk-based inspection techniques are used to evaluate equipment, reduce maintenance costs, and increase assurance that equipment is available. In this method, possible actions and consequences and results of each action are specified and based on the results of benefit and cost, prioritization is done. At this stage, the best action that leads to reducing, stopping and failing the equipment are selected (Vianelloa et al., 2019).

By identifying the components of safety in accordance of researcher’s views, management will be able to make better decisions about accidents and safety costs in the organization. The purpose of this study is to identify and rank the cost components of safety. These factors are based on library studies of the gas refinery. The importance of safety in refineries, especially gas refineries, is such that obtaining a permit from the safety department is required before starting any activity in the refinery. The distinguishing feature of this research is the forward-looking approach, identifying safety cost factors and presenting a model that will definitely enable management and the model of safe manager. In refineries that processes are accompanied by high heat and pressure, there are the heaviest risks and uncertainties in this chain. Therefore, insurance companies try to use scientific methods in estimating errors and safety assessments so as not to suffer untimely losses. Therefore, methods of failure analysis and impact assessment are implemented in insurance organizations (Ghasemi et al, 2015).The above procedures are methods that try to investigate events from a retrospective perspective, based on realized events. According to the information of the International Labor Day, accidents and occupational injuries in 1997 amounted to 9,996 people, which is a decrease of 6% compared to the previous year.

Accordingly, the third leading cause of death in the world and the second leading cause of death in Iran after accidents are work-related accidents. According to the latest statistics of the International Labor Organization published in 2019, annually 2.780 thousand workers. Die due to accidents and diseases caused by work and 374 million workers suffer from occupational accidents. The cost of accidents and occupational diseases is about four percent of each country's GDP. Therefore, observing safety tips and identifying the components that affect safety can play an important role in preventing accidents.

The purpose of safety assessment and components of safety cost is to provide a path that in addition to fulfilling the social duty of the organization to help identify effective components. These components have a high impact on the safety cost and guide managers in monitoring safety costs in the right centers. The safety route in organizations will not be effective without identifying the safety cost and safety components. In this way, prioritizing the components is the beacon that provides the organization with public reputation. Organizations perform their legal duties by taking safety measures. Performing social duty is another aspect of safety care. Other aspects of safety assessment include performing religious, religious and moral duties. Every person is obliged to save his life. The safety cost reflects the components that

management uses to have a high impact on safety and provide cost effectiveness.

What has been done in previous articles on safety has been island-based and focused on a selective factor, for example, accidents caused by manpower error or accidents caused by facilities. In this article, all cost components are examined and there is no bias in proving the importance and priority of the components. The purpose of this article is not to provide accounting figures for calculating the safety cost. Efficient production and production operations require measures and requirements, one of which is to work safely and manage the psychological and social process of safety. Working safely and preventing accidents before the need for structure is actually a kind of culture. One of the most important ways to prevent accidents is to create and strengthen a safety culture. Safety culture is rooted in personnel psychology and human resource planning. Preserving human resources and creating positive thinking in them is exhibited through managerial actions and approaches. Occupational accidents leading to the death of Iran in 1398 were equivalent to 726 people. In other words, there is almost no day when at least two fatal work accidents do not occur for workers. If we add to this the number of occupational accidents and consider the subsequent consequences, the cost of accidents will be terrible for society. In the rapid movement of industrialization, lack of serious attention to the principles of industrial safety has led to an increase in the rate of occupational accidents in the workplace. Therefore, the theory of safety culture among employees has not been successful so far. In this research, scientific safety and organizational accidents have been studied to identify factors and introduce them to management that will expand the safety umbrella on the employees of the organization.

A feature of past research is that it investigates an accident and compares the cost of the accident to the cost of safety tools and equipment.

Also, many safety studies have a review aspect. Safety as a culture, safety as a missing production link, safety as a forgotten process, safety at the workplace, safety and health at work and safety at work are some of the topics that review safety and provide solutions based on the narrative of past research. The calculation of safety based on the procedures of willingness to pay or conditional valuation expresses calculations that in different situations and different moods of people can have many deviations. Tolerating unsafe conditions in exchange for receiving money and safety pricing accordingly, will not allow increasing safety in the organization. Therefore, it seems that providing component models that challenge safety factors would be a better approach. Also, fluctuating and changing views will not be reliable in these methods. Similar research in a comprehensive review of safety in the refinery, from the perspective of equipment, facilities and manpower and the relationship between safety and safety cost and model presentation in order to prioritize the most important components are the features of the present study. In this research, the top components are explained in detail and the factors related to each component should be considered by safety experts.This article tries to present the safety cost components and prioritize them. This goal is the key to managers' success in controlling costs.

2. Literature Review

What are the factors influencing the safety cost? What is the cause of accidents? Is it possible to reduce the safety cost by managing these factors?

One way to look at safety cost is to look at accidents. The past is the beacon of the future. Knowing the path to victory is tantamount to avoiding the path of defeat.

Experience and training has a significant impact on workers' awareness of safety in the workplace and reducing accident statistics. Over 60% of the fatal accidents in 1392 were people who had secondary and high school education and were deprived of higher education. In examining the data recording system events Center for Environmental Health and Labor Ministry of Health and Medical Education in 1392 found that over 72 percent of the deaths were caused by accidents in the workers with work experience of less than one year (Asadi et al. ،2016).Organizations must observe moderation when it comes to safety tips. Providing safety advice and solutions will not always reduce accidents. Organizations with the motto of safety first work later try to running of safety culture. But management approach in accepting this concept is important. Providing non-enforceable solutions or safety solutions and recommendations that are not implemented in the system or emphasized by management, not only will not reduce accidents, but will disrupt the safety process and the occurrence of accidents. Therefore, in some cases providing safety advice has no causal relationship with occupational

accidents and operates independently (Aghajani, 2010).

One way to evaluate the performance of the safety system is to use a prospective index. These indexes are preventive and enable organizations to prevent and help them develop improvement plans and corrective actions before events occur. Indicators are active and include unsafe behavior rates, safety climate, accident susceptibility and rate of near-miss occurrence. According to expert's opinion, the rate of unsafe behaviors is the most important and the rates of occurrence of quasi-accidents are the least important in assessing safety performance (Barkhordari et al., 2014).

Positive and strong safety culture in employees is one of the safety measures. A strong positive safety culture among employees will facilitate the organization's move towards higher safety standards. An investigation of safety shows that more than 90% of industrial accidents are related to the human factor and safe behaviors in industries cannot be institutionalized based only on technical engineering measures and the establishment of safety rules and regulations. Therefore, by creating a positive and effective safety culture, people can be aware of the existing dangers and reduce accidents in the workplace. Examining the safety culture in five dimensions of training, work environment, priority to safety, information exchange and management commitment shows that priority to safety was most important and management commitment was the least important. Also, increasing the age will reduce the safety culture (Shekari et al., 2014).The first priority for improvement of safety value is classes and training courses, and in the second to fourth stage, respectively, creating safety regulations in the administrative and production sectors, investing in medical care, safety equipment, purchasing new machinery, equipment and technology, are ranked (Masoud Nejad et al., 2018).The study of accidents in 2001 to 2003 in the insured of Tehran showed that in the deceased, the factor of experience and work precedent as one of the cases affected in the occurrence of accidents. The highest number of deaths is in the work precedent of zero to five years and the lowest number of deaths is in the work precedent of 26 to 30 years (Mohammad Pham, 2007).

In another study, 10583 occupational accidents registered in the database of the Ministry of Cooperatives, Labor and Social Welfare in 2012 were examined. Investigation of accidents confirms that most of the missed work days due to accidents occur in married people and employees with a history of less than one year (Atrkar Roshan, 2015).

Mooudi et al in Mazandaran wood and paper industry have studied medical records and accident registration forms in the years 2007 to 2012 and lack of sufficient experience has been suggested as one of the causes of accidents (Mooudi et al., 2015). The study of occupational accidents in Qazvin workers in the years 2011 to 2013 also shows that age and experience is one of the significant cases related to accidents. 25-29 years is also considered as the age in which the most recurrence of accidents has occurred (Sabeti Motlagh et al., 2015).In safety-related decisions, if cost-benefit analysis is used, this method can have many advantages in making decisions, and based on this, we can make rational decisions related to safety, safety promotion and management. Due to the high uncertainty, simple methods of capital budgeting work well, and there is no need to use the time value of money technique. The Return of capital period and the benefit-to-cost ratio provide sufficiently accurate estimates. Also, the relationship between safety and stock value is hazy and stock price change is an issue that cannot be met in real life (Monem et al., 2016).In a study entitled "Developing a New Model for Evaluating and Ranking Health, Safety, and Environmental Performance," the HSE Performance Evaluation Model were identified with nine criteria: Safety Outcomes, Health Outcomes, Environmental Outcomes, Processes, Economic, and Social Outcomes , Cultural, policy and strategy, leadership, partnerships and organizational resources and staff management, and 19 sub-criteria and 157 guidelines (Peysepar et al., 2017). In the study of combined cycle powerhouse, safety factors in three categories of management and manpower and equipment have been considered and management factors have been the most effective and human factors have been the most influential factors (Modiri et al., 2018).

Table 1: Summary of internal research concepts in the field of safety and accidents

Year	Researcher	Issue
2001-2009	Mohammad Fam et al.	Mortality due to accidents in people with little work experience
2007-2012	Moaoudi et al.	Lack of sufficient experience The cause of the accident
2008	Aghajani et al.	Lack of relationship between safety advice and occupational accidents
2011-2013	Sabeti et al.	Lack of sufficient experience of the causes of the accident
2012	Atr Kar Roshan	the most popular working day in married people and employees with less than one year experience
2013	Asadi et al.,	The cause of accidents and the frequency of accidents in workers with a history of less than one year
2014	Barkhordari et al	choosing a prospective and preventive index such as insecure and friendly behaviors
2014	Shekari et al.	Assessing safety culture in five dimensions and prioritizing safety
2016	Monem et al.	Using new tools of Balanced Scorecard or cost-benefit or budgeting methods such as repayment period in safety cost calculations
2017	Peysepar et al.	Assess the performance of HSE unit based on nine criteria
2018	Masoudnejad et al.	classes and training courses - Developing safety regulations - Investing in safety equipment
2020	Modiri et al.	Identify and prioritize factors affecting safety performance with the combined approach of DEMATEL and fuzzy network analysis process (a combined cycle powerhouse)

The issue of calculating accident costs was first raised by Henry in the 1930s. He defined direct and indirect costs for accidents and stated a ratio of one to four for them. Of course, this range was challenged in later research. Grimaldi later proposed the division of covered and non-covered insurance costs in 1975. In Finland, there is an accident information system that allows insurance to be provided to insurance without the need for written reports (Altonin et al., 1997). Preventive measures play an important role in reducing work accidents. These measures can be in three forms: "optional", "incentive leverage" and "mandatory". Brody classifies health safety costs into two categories: incident and prevention costs. In the theory of indirect cost of accident prevention, Brody has divided prevention costs into three categories. Fixed costs include the minimum applicable standards and variable costs depending on the recurrence and severity of defined accidents and the costs of analysis and research on accidents (doctor, nurse, health specialist, etc.). The performance of these people in public education is a fixed cost and in the investigation of a specific incident, the cost is variable. Unexpected costs are costs that remain hidden when purchasing equipment or manufacturing a product, such as equipment needed to reduce the noise or chemical pollution of a facility. Incident costs are classified into two categories: direct or insurance costs and indirect costs. Direct costs or insurance are the most familiar part of the costs and are the costs that the organization pays to protect against the consequences of special events. Indirect costs are also six parts and include the following:

1) Salary cost: Salary and benefits paid that are not spent on time.
2) Material waste cost: consumables for repairing facilities or raw materials or defective and damaged manufactured goods
3) Management time: The time spent by management personnel is reported, such as doctors, nurses and health specialists. Of course, the time spent in research and development should be considered as part of prevention costs.
4) Production damage: non-production damage from the time of the accident until the commissioning of the facility and replacement to the normal process
5) Other expenses: Expenses not covered by insurance (first aid or transfer to hospital and insurance assistance)
6) Intangible (indefinable) expenses: such as public hatred, destructive labor relations or increase in insurance premiums

There is a huge difference between prevention and incident costs in terms of time. Pre-accident and post-

accident prevention costs. The two exceptions include the cost of research and analysis, the cost of prevention as it is likely to reduce the future incidence of the accident and the cost of insurance paid at the beginning of the financial period and before the accident (Brody et al., 1990). Safety requirements are defined at the grassroots level for organizations. Examples of these requirements include hiring safety experts, purchasing safety equipment, or holding mandatory courses. Legal requirements and possible penalties require organizations to comply with these requirements. It is more effective than basic safety measures (Feng, 2013).

A review of the last 16 last studies shows that the indirect costs of accident costs in the construction environment can be classified into thirteen possible components. These thirteen components are:

1) Loss of non-production due to injury to the foreman (Henrich 1931, Simons and grimaldi 1956, Heinz 1991)
2) Loss of non-production due to injured workers (Henrich 1931, Heinz 1991, Monerri 1999)
3) Loss of non-production due to other workers close to the accident (Henrich 1931, Lofer 1987, Heinz 1991)
4) Loss of non-production due to replacement with injured worker (Loefer 1987, Everett and Frank 1996, Moneri 1999)
5) Loss of non-production in the investigation of the causes of the accident (Simmons and Grimalid 1956, Heid and Harcourt 1997)
6) The cost of workers' supervision or cooperation (Henrich 1931, Simonzo Grimalid 1956, Heinz 1991)
7) Loss of defective equipment, facilities, property, materials and manufactured goods (Henrich 1931, Brody et al. 1990, Heinz 1991)
8) Injury transfer costs (Simmons and Grimaldi 1956, Heinz 1991, Moneri 1999)
9) Consumption of first aid in the accident (Heinz 1991, Heid and Harcourt 1997)
10) Compensation required for the accident (Simonz and Grimaldi 1956, Lofer 1987, Everett and Frank 1996)
11) Crimes and Legal Damages (Leopold Leonard 1987, Hade and Harcourt 1997)
12) Loss of order stoppage, especially in the project (program disruption (Brody et al. 1990, Everett and Frank 1996)
13) Other assistance to the injured worker other than the Labor Administration Act (Henrich 1931)

A review of 47 construction projects in Singapore shows a positive correlation between the direct and indirect costs of accidents and the degree of involvement in second-hand contracts. The importance of calculating accident costs in construction projects is also emphasized (Feng et al., 2015). The development of safety regulations in the United States was further emphasized after the 2010 explosion in the Gulf of Mexico. These rules are discussed from three aspects. The first is that the offender must pay a fine. The second is that society is more sensitive to the loss of numbers than the loss of an individual. Third, in the case of incidents that can be prevented, the offender will be prosecuted as a criminal. Cost-benefit analyzes always consider the occurrence of accidents as uncertain and probable for the occurrence of accidents that will vary according to the circumstances. However, this probability will never be zero. In another view, it is stated that all accidents are preventable and major accidents are caused by poor management. Therefore, the jurisdictions consider these crimes as criminal offenses. In each case, they have seized it, despite obstacles we can scarcely imagine. "However, the US presidency has not been able to enact rules that outweigh the costs (Hopkins, 2015). Monetary information is needed to properly manage safety-related decisions. In addition to focusing on financial information, management accounting should focus on non-financial information such as safety improvement, strategic safety objectives, and employee relationships. In security investments, the monetary costs of investing are usually well known, but it is difficult to calculate the monetary value of the benefits. Therefore, it requires cost-benefit assessment methods, including non-financial benefits and accident prevention values. Most management accounting decisions are influenced by non-accounting factors. This is more evident in the issue of safety, which is related to a person's feelings and perceptions, and emotions play a stronger role than calculations. The concepts and methods that exist to evaluate the profitability of a safe investment should be developed from a management accounting perspective. Fundamental problems in uncertainty, analysis-environment assessments, and benefit-cost amounts are always present and complicate the causal

relationship between safety investments and future benefits (Tapura et al., 2015). Occupational accidents will be very costly in modern society. The European Agency for Occupational Health and Safety estimated in 2001 that 4.6 million occupational accidents per year would result in a loss of 146 million hours of work. The Project Cost Systematic Analysis Project was launched in 2001 by the Aarhus University of Commerce and the British Multinational Professional Services Company with funding from the Danish National Environment Agency. The accident cost assessment showed that 67% of occupational accident costs were monitored by the accounting system of Danish companies and the remaining 23% were hidden from their view. The highest occupational accident cost for an organization with 3,600 workers is estimated at US $ 682,000. Information of incidents cost, regardless of their monetary value, should be included in the organization's budgets and used in management decisions and controls. Richardson et al. State that there are six factors involved in calculating the cost of accidents. The six factors of Richardson and the monetary composition of injury costs are as follows:

- Absence cost 65%
- Disruption of operations 14%
- Communication4%
- Executive cost 13%
- Support and prevention plans 3%
- Other costs 1% (Richardson et al., 2004).

Of course, in a very beautiful model, Altonin draws the accident tree for the 12-month events in 1986 and 1987 in 12 furniture factories and considers three groups to be affected by the results of the events. These three groups are in addition to the organization, individuals and national economy. The identified accidents had a total of 4300 consequences and an average of 20 cases per accident. These consequences for people include injuries, temporary disability, loss of production stoppage, the cost of medical treatment and finally each accident reduces productivity. Has brought. The above factors are a set of factors that have been addressed in the incident outcome tree (Altonin et al., 1996). In order to design an effective and scalable safety plan in the organization, three main factors must be considered: people (knowledge, beliefs, values, motivations, abilities and personality of people), behavior (adaptation, coaching, cognition, Communication and explicit importance) and the environment (equipment, tools, machinery, tool management and engineering) (Sokadarin et al., 2012). Safety culture is very important for organizations and institutions. Therefore, creating incentive mechanisms in encouraging organizations to comply with safety requirements can have many benefits in creating a safe environment. Expenditures made by organizations as investments in environmental and workplace safety, such as setting up a new clinic to serve the community and equipment for personal protection and education, can have significant results. Occupational safety and health will reduce injuries, increase productivity and generate a secure income for the working family. For example, certification for a shipping company in Bangladesh has created a competitive advantage that will lead to access to global markets and will have intangible benefits such as trust, motivation and safety, and will certainly have a significant impact on cost-benefit analysis (Confirmation and Et al., 2015). Management is responsible for implementing a safety approach in the organization. Continuous emphasis on continuous safety improvement should be applied by management to be a model in achieving safety in the workplace through safe notices and actions. On the other hand, imbalance or in other words, excessive monitoring and control of management will be harmful in achieving a safe work environment (Molnar et al., 2018).

Older theories of occupational safety have played an important role in reducing hazards and occupational safety. Global statistics show that the number of work accidents can be reduced but cannot be zero. In the theory of occupational safety success, the main components of the system are identified. , The environment and management. In the traditional view, strategies such as increasing the protection of equipment or hiring additional supervisors are proposed. But these strategies do not guarantee sustainable success by entering the system energy at once. It also has a high investment cost and imposes a heavy burden on the system. According to the second law of thermodynamics, the entropy of a closed system increases until it reaches equilibrium. During the work, in the first stage, the worker's entropy increases. In the second stage, in order to solve the problem, an observer must be hired. In the third stage, over time, the worker's entropy increases again and the previous steps are repeated. The cycle was a repetition of the

previous cycle. In the fifth stage, the system load is increased and it is not possible to increase the monitor. Worker entropy is elevated and occupational safety will not be successful. In a successful occupational safety system, information is collected from system components and the entropy development and reduction process is formed. For example, in the case of overwork, the worker blinks and the decreasing trend is observed from six o'clock in the morning. In order to reduce entropy, we warn or send him to rest at nine o'clock in the morning. At this stage, a decrease in entropy is created. In later stages, increasing entropy will have a similar effect. The dynamic data model of occupational safety entropy based on the theory of occupational safety success collects information and ensures the safety of the system by investigating the occurrence of system changes (Darring Woo, 2019).

To analyze the work accident cost on occupational safety and health risk handling at the construction project of Hasanuddin University Faculty of Engineering. An explorative study with a retrospective approach, analyzed the occupational accident records and Microsoft Excel for the safety cost data. The value of the benefit-cost ratio is 1.2 or ≥1, which means the occupational safety and health risk program cost investment by ADHI Company is categorized as beneficial for the company. The safety cost data presented in this paper may be useful for practitioners to direct resource investment.

Table ۲: Summary of internal research concepts in the field of safety and accidents

Year	Researcher	subject
1931	Henrish	Divide the cost of accidents into direct and indirect (ratio 1 to four)
1975	Grimaldi	Coverage and non-coverage costs of insurance
1990	Brody	Divide the cost of accidents into incident costs and prevention costs
1996	Altonin et al	Drawing an accident tree Investigating the impact of an accident on an individual. Society. Economy
2004	Richardson et al	Seven criteria for calculating the cost of accidents
2012	Sukadarin	Develop safety plans based on three factors: individual, behaviors, and environment
2013	Feng	Voluntary safety measures are more effective than basic safety measures
2015	Tapura et al	It is difficult to establish a causal relationship in the field of safety and future benefits
2015	Feng et al	Direct and indirect costs (13 parts)
2015	Hopkins	Benefit from the cost of following safety rules
2015	Tidei et al	Safety culture is an effective way to streamline safety and reduce accidents
2018	Molnar et al	Holding a training course is too harmful supervision
2019	Darning Woo	Occupational safety success theory
2020	Furqaan et al	Analysis of work accident cost on occupational safety and health risk handling at construction project of Hasanuddin University the Faculty of Engineering

3. Methodology

The present study is a review for the first time and examines previous research and articles on the safety cost and accidents and the identification of safety components. In the second stage, using data envelopment analysis (fuzzy AHP) techniques, the identified factors are classified. The statistical population includes safety experts, which includes 12 experts in the field of HSE and safety experts, including 3 academic experts and 9 industry experts. In this study, cost-effective safety components have been identified in thirteen branches. Managing, controlling, and monitoring priority indicators focuses on solving problems that are considered complex at the safety cost.

3.1. Research question

The present study involves the search for answers to two important questions about the cost of safety. Given the importance of safety and its relationship with the most important asset of the organization (human resources) on the one hand and creating a safe environment for work, the first question of the research is to identify the costly components of safety. The next step is to prioritize the criteria using the opinions of safety professors. Creating weight, scale, and number will enable management and enable managers to analyze safety issues.

3.2. Fuzzy AHP method:

So far, several management methods have been developed for group decision making such as nominal group technique, Delphi and brainstorming techniques, each of which has disadvantages in terms of time, cost and rigidity. Fuzzy AHP technique is a new method that to some extent this Solves problems. This method not only has the advantages of the above methods but also in terms of its mathematical logic has the ability to combine quantitative and qualitative criteria to compare multiple options. The goal in fuzzy theory was to eliminate and neutralize verbal ambiguities. The process of hierarchical analysis reflects natural behavior and human thinking. This technique examines complex problems based on their interactions and solves them in a simple way. Fuzzy numbers are expressed in two forms: triangular fuzzy and trapezoidal fuzzy, the most common of which is triangular fuzzy. Triangular fuzzy numbers are given as (l, m, u). The parameters m, l and u are the smallest, most probable and the highest possible values, respectively. The steps of fuzzy AHP by Chang method are as follows:

Step 1: Draw a hierarchical diagram

Step 2: Define fuzzy numbers corresponding to fuzzy expressions for pairwise comparisons.

Table 3: Definition of fuzzy expressions

Score	Fuzzy numbers	Linguistic variables	Score	Fuzzy numbers	Linguistic variables
3,4,5	4	Relatively important to important	9	9,9,9	Extremely important
2,3,4	3	Relatively important	8	7,8,9	Very important to extremely important
1,2,3	2	Matched importance to relatively important	7	6,7,8	Very important
1,1,1	1	Equal importance	6	5,6,7	Important to very important
			5	4,5,6	Important

Step 3: Formation of an even comparison matrix using fuzzy numbers At this stage, according to the experts' answers to the questionnaires, a matrix of pairwise comparisons containing fuzzy numbers is formed.

Step 4: Calculate the matrix S (triangular fuzzy numbers) for each row of the pairwise comparison matrix

(Equation 1)

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^{j} \right]^{-1}$$

Step 5: Calculate the degree of magnitude of S relative to each other

(Equation2)

$$V(M_2 \geq M_1) = hgt(M_1 \cap M_2) = \mu_{M_2}(d) = \begin{cases} 1 & \text{if } m_2 \geq m_1 \\ 0 & \text{if } l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)} & \text{otherwise} \end{cases}$$

(Equation 3)

$$M_2 = (l_2, m_2, u_2) \;\; 9 \;\; M_1 = (l_1, m_1, u_1)$$

In the above relation, two fuzzy numbers are triangular.

Step 6: Calculate the weight of the criteria and options in the pairwise comparison matrices. In this step, it is sufficient to obtain the non-normalized weight vector by calculating the minimum value calculated in the previous step.

Step 7: Calculate the final weight vector by normalizing the previous step matrix In order to rely on the above data, this information must be consistent. Incompatibility rate is an indicator that measures the compatibility of experts' responses to evaluations and pair comparisons.

Gogos and Butcher (1998) suggested that the following steps be performed:

1) Divide the fuzzy triangular matrix into two matrices. The first matrix consists of middle numbers and the second matrix contains the geometric mean of the upper and lower limits of triangular numbers.
2) The weight vector of each matrix should be calculated using the hourly method.
3) Calculate the largest eigenvalue for each matrix.

4) Compatibility indices are calculated for each matrix.
5) To calculate the incompatibility rate, the above value should be divided by a random index.

The value of the random index is a fixed number. The allowable range is less than 0.1.

4. Results

In a library review of the cost-effective components of gas refinery safety, the following factors have been inferred as key indicators or criteria:

Figure 1: Chart of goal hierarchy and criteria

Prevention of car accidents	**Target : Identifying and ranking the effective factors in the price safety cost (gas refinery)**
Prevent people from getting caught	
Prevention of explosions and fires	
Fall prevention	
Prevention of ergonomic hazards	
Avoid the dangers of high pressure lines and equipment	
Prevention of electrical hazards and other energy equipment	
Prevention of machine hazards	
Studies and planning for planning and prevention	
Prevention of errors in construction operations at the gas refinery	
Prevent the dangers of hazardous chemicals in the gas refinery	
Prevention of health risks in the refinery	
Prevention of human error	

Each of the above factors includes one or part of the activities of the gas refinery. In each section, there is the possibility of accidents and the following definitions are provided for these concepts:

- Car accident prevention: includes car safety and location and road.
- Preventing people from getting caught: Safety in cranes, limbs, transportation, etc.
- Prevention of explosions and fires: combustion of furnaces, heat of fields, movement of flammable materials, etc.
- Prevention of falls: Safety in walking surfaces and reducing fall injuries, etc.
- Prevention of ergonomic hazards: Stress and strain are skeletal and ergonomic disorders.
- Prevention of the dangers of high pressure lines and equipment: The dangers of gas and pressurized lines.
- Prevention of dangers of electricity and other energy equipment: energy controller and safety equipment, etc.
- Prevention of machine hazards: The guard is the threshold of danger and safety of machine activities, etc.
- Studies and planning for planning and prevention: educational activities and ways and facilities to protect people
- Prevention of construction operation errors in the refinery: types of construction activities Refinery chemical hazard prevention: Includes operational chemicals.
- Prevention of health hazards: non-operational chemicals (refrigeration, cleaning, etc.)
- Prevention of human error: includes personal, organizational, environmental and occupational factors.

For indicators relation to the target , prevention of: explosions and fires, human error, hazards of electrical and other energy equipment, hazards of high pressure lines and equipment, machine hazards, hazards of hazardous chemicals in the refinery, operational errors Refinery construction, falls, car crashes, ergonomic hazards, studies and planning for planning and prevention, prevention of human entanglement, and prevention of health hazards have gained the most importance and priority, respectively.

Table 4: Final weights of research criteria

Number	Indicator	Index score
1	Prevention of car accidents	0.067
2	Prevent people from getting caught	0.033
3	Prevention of explosions and fires	0.13
4	Fall prevention	0.074
5	Prevention of ergonomic hazards	0.061
6	Avoid the dangers of high pressure lines and equipment	0.092

Number	Indicator	Index score
7	Prevention of electrical hazards and other energy equipment	0.111
8	Prevention of machine hazards	0.086
9	Studies and planning for planning and prevention	0.04
10	Prevention of errors in construction operations in the refinery	0.079
11	Learn about the dangers of hazardous chemicals in the refinery	0.086
12	Prevention of health risks in the refinery	0.028
13	Prevention of human error	0.112
Total points		1

Inconsistency ratio: CRm: 0.058, CRg: 0.0135 (Inconsistent matrix) Compatible consistent

5. Discussion and conclusion

Safety is actually a measure of being away from danger or getting rid of unacceptable risk. In general, reducing financial and human losses in industrial units is directly related to increasing economic profitability, reducing costs, saving time, preventing a decline in workers' morale. Therefore, it is very important to pay attention to the health of human capital in order to eliminate or reduce occupational accidents. Safety costs are not a good cost for managers. Accidents incur costs that organizations try to avoid. In addition to the financial aspect, the occurrence of these costs will also affect the organizational reputation and the social aspect of the organization. Managers will be responsible for implementing safety principles. Customers in any organization are interested in buying from an organization that respects citizenship rights and provides a safe environment for employees. Failure to pay attention to this can lead to employee apathy. Due to the importance of the issue, the organizational nature of industrial accidents is considered and various studies have been conducted to identify managerial, organizational and environmental factors that affect the occurrence of accidents. The term bloody diamonds refers to products that were produced by forced labor and non-compliance with safety. These products lost many of their customers due to hatred of employers. Customers are interested in buying products that do not respect human dignity and the rights of individuals. These seem to be sufficient in relation to the importance of safety and safety assessment, albeit in a limited way.The occurrence of its expenses is not normal and they do not have a clear causal relationship with the benefits. In other words, it is difficult and impossible to determine what safety action caused the accident. Assessing the safety cost and effective components will enable effective control, rational guidance and continuous monitoring of safety costs for management. In this study, 13 effective factors in the safety cost have been extracted. These components are the factors that are the focus of accidents in gas refineries.

Improve safety, reduce accident rates, reduce repair costs, maintain equipment, insure, avoid cessation of production and make safety a core value. Safety components are the place where expenses are realized that put significant programs on the agenda to reduce potential accidents that will be implemented over time. In order to enable management to focus on priorities, the top 5 factors that have gained over 50% of the importance in safety components have been selected and presented as a star model. These five factors are the cornerstones of management advancement, the consideration of which will determine the realization of safety costs at the final destination. Ignoring the safety tips will be a decisive and catastrophic failure. Certainly, addressing the final safety situation in the organization, by controlling these 5 factors, will be easier than the sum of the factors, because up to 50% of the final weight of the factors affecting the safety cost.

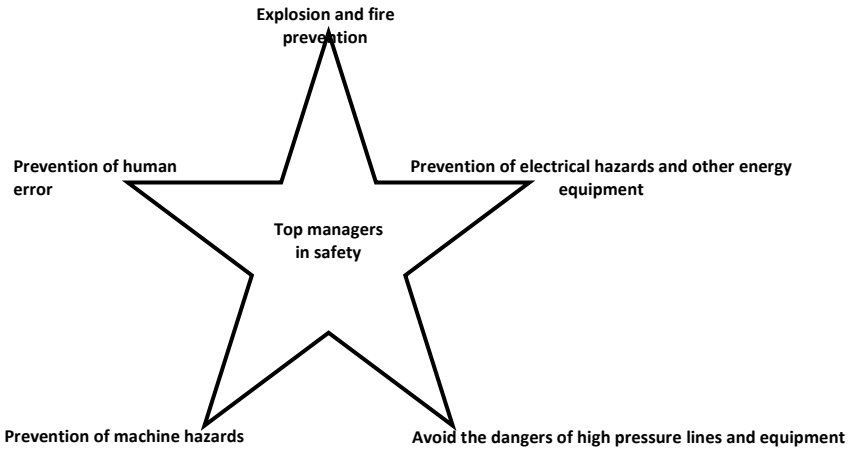

Figure 3: Star diagrams of the most cost-effective safety components

In gas refineries, explosions and fires are different from oil refineries and lead to highly uncontrollable accidents. On the other hand, in prioritization, this factor has found the most important priority. Preventing fires in areas full of flammable materials, especially gas and condensate, is one of the high-risk activities and is committed to safety. Explosions and fires, in addition to facilities, will cause damage to specialized manpower and stop production. A variety of methods in this regard, based on a survey of HSE staff and the inspection office will include preventive and mitigating effects in the event of occurrence. Cost in this area will have a high impact on safety and enhance the value of safety.

Human errors in the second category indicate the importance and necessity of paying attention to the workforce and the issue of training and motivation in employees. In the future stages of the research, the possibility of analyzing the human factor in four levels of job, individual, organizational and environmental, will provide the management of this factor skillfully. Many studies have tried to examine the monetary effects of human error. Manpower in the workplace is faced with issues such as fatigue and routine. Discouraging behaviors and mental pressures can increase the incidence of human error. Therefore, in addition to increasing the efficiency of facilities, management should try to motivate human resources and always lead this valuable asset. Officials of technical inspection and HSE consider holding training classes and appreciation of the best people of the course as well as providing gifts to the employees' families to be effective in reducing human errors.

Electricity as a source of energy and high pressure gas lines are in the third and fourth ranks. Accordingly, the use of electrical safety tools and control of pipelines become more important.In addition to safety equipment, organizations should consider savings in electricity. But safety should not be sidelined and saving should be a priority. Power supply is possible from two sources of national lines or power generators. In each case, the World Health Organization monitors the practice and sets out basic safety principles. Electricity in refineries will be accompanied by burns due to high pressure. Therefore, identifying potential hazards and following the instructions in case of out-of-control electrical installations in repair activities has always been considered by refineries. Pipeline calibration and periodic corrosion monitoring are the executive factors that are presented in refineries as risk reduction factors for pressure pipelines. Extensive corrosion cost analysis implemented in all gas refineries and facilitates pipeline control. Pressure drops and other signs of leakage can also be detected by safety facilities.

Machine hazards are also pivotal activities that redouble the importance of barriers and machine safety in periodic monitoring and predicting the exit routes of people getting stuck in places. Refineries sometimes have automatic operations that in some cases require the presence of manpower and performance review. This inspection should be done by observing the safety distance and using safety equipment and the exit routes should always be used immediately. Therefore, machine hazards and surveillance along with safety measures are important in machine activities. Finally, the promotion of managers in terms of safety and non-occurrence of accidents and safety training from accidents is by no means a desirable process. Safety control through cost-effective components of safety and prevention of accidents can reveal a different meaning of safety management. This research has deep roots in technical, equipment and repair principles and challenges safety economics. In what cases should the organization spend to improve safety? Is it enough to buy equipment and secure the manpower? In this research, technical principles in the safety cost were discussed. In many cases, technical and practical principles were stated that are applied in refineries through the HSE organization and technical inspection and will undoubtedly have an impact on the safety of the organization.

Paying attention to the components and each of the above criteria will increase the safety and health of the organization's employees. Each of the above criteria can be measured based on the views of safety experts and managers of the organization. The following criteria state the factors that not only threaten the health of employees, but also neglect them, reduce productivity and increase insurance costs, and even charge people with suspicion and take them to court. . What is important is that management pays attention to the importance and magnitude of the risk and controls precautions. Moving blindly and relying on unscientific criteria reduces the ability and ability of management to control and promote safety. Therefore, based on the opinions of industry experts and adapting to the views of elites about the components of safety, a safe and dynamic organization and sustainable production will be achieved.

Table 5: sub-criteria related to superior safety cost indicators

Prevention of explosions and fires	**Prevention of electrical hazards and other energy equipment**
Prevent combustion of vapors by engines	Energy control has potential risks
Furnace and burner combustion sources	Instructions and training to ensure the safety of workers
Risks of working in hot, explosive and flammable places	Safety against electrical equipment
Potential fire hazards associated with bulk transportation of petroleum products	**Prevention of of high pressure lines dangers and equipment**
Generation of static electricity in plastic pipes	Compressed gas and equipment
Heat protection	Pipelines under pressure
Heat in the gas field	**preventing human error**
Sour gas enters the absorption tower	Individual factors
Amin entrance to the absorption tower	Occupational factors
Rich Amin of the absorption tower	Environmental factors
Rich Amin enters the heat exchanger	Organizational factors
Rich Amin output of the converter	**Prevention of machine hazards**
Weak Amin the output of the resuscitation tower and the entrance to the heat exchanger	**Obstacle guard for danger threshold**
Rich Amin enters the revival tower	Getting stuck in a place of danger
Amin refluxed from the resuscitation tower	Machinary safety

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