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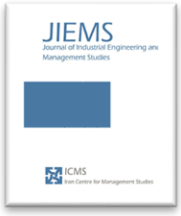

Prioritization of effective parameters related to health, safety& environment (HSE) promotion utilizing fuzzy logic approach and house of quality (HOQ) method: case study iran barite group

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Abstract

In order to be competitive, it is an obligation for companies and service centers to identify, evaluate and control risk and environmental aspects of their activities. Due to technical and financial constraints, it is required to prioritize the risks and control measures with greater accuracy. In the framework of the HSE-MS system, for the first time, risk evaluation of industrial activities and services, has been implemented using fuzzy Quality Function Deployment. In this approach, characteristics such as mutual effects of different risks and environmental aspects of industrial activities, risk estimation, and positive and negative aspects of activities have been considered in RPN computation. The application of fuzzy logic reduces the ambiguity of the linguistic parameters. In the case study of the Iran barrit falat it appears, that operation and impact of risk assessment methods and environmental aspects of activities, evaluation criteria and the priority actions has been performed more precisely in comparison with traditional methods of risk assessment.

Keywords: House of quality (HOQ); Health Safety & Environment (HSE); fuzzy logic; ISO14001:2004; OHSA18001:2007; Quality Function Deployment (QFD).

Paper Type: Original Research

1. Introduction

Having a safe life away from dangers has been the dream and goal of all humans throughout history. Throughout the history of human society, it has always been trying to achieve more comfort and convenience, and in this direction, it has tried to take over all the equipment and the environment. The occurrence of many health and safety problems and the increase in environmental pollution took a new form with the advancement of technology, and this urgent need was felt to create codified plans and standards in the field of safety, health and environment. Among these standards are OHSAS18001:2007 and ISO14001:2004. Subsequently, a combination of these two standards was created called Safety, Health and Environment Management System (HSE-MS). Among the main factors of HSE-MS improvement is risk assessment and environmental aspects. Risk identification and evaluation will be the guiding factor to identify the priority of risks, environmental aspects and the priority of control measures. Because companies have limited financial and technological resources, they try to eliminate the factors that generate safety and health risks, as well as the obvious environmental aspects in order of priority. In this way, both the demands of the legal authorities are fulfilled and the possibility of securing work environments and preventing environmental pollution is provided financially and technologically (Text of OHSAS 18001 standard). According to the announcement of the General Department of Labor Inspection of the Ministry of Cooperatives, Labor and Social Welfare, the number of accidents caused by work in 2011 compared to the previous year was accompanied by a 28% decrease. In such a way that it decreased from 16,000 work-related accidents in 1990 to 12100 in 1991 (asabati, 2012). This is while, according to the statistics of the Forensic Medical Organization of the country, despite the decrease in the number of accidents because because of the high intensity of the accidents that occurred in 2019, the number of deaths caused by these accidents increased by 19.1%, from 1507 people in 2019 to 1795 people in 2019. In addition, the most accidents caused by work in 2019 were in the construction industry, which accounted for 37.5% of the accidents (Forensic Medicine Organization, 2012). The 2012 World Environmental Performance Index has been published by "Yale" International University, while Iran is ranked 114th among 132 countries in the world with a drop of 36 places compared to 2010 (Yale University, 2012). This statistic shows the fact

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that, first of all, a limited number of organizations are familiar with the current world standards and use them. Secondly, the safety, health and environmental standards are not properly implemented due to the inappropriate approach in choosing the appropriate method of risk identification and assessment. It is necessary to evaluate occupational health and safety risks and environmental aspects in order to maintain specialized and non-specialized human resources in every company and comply with environmental standards and requirements that increase the reputation of the organization among customers and neighbors. And it prevents responsible organizations from committing crimes related to environmental pollution. Because the methods of evaluating occupational health and safety risks and environmental aspects are general. It is necessary to revise these patterns depending on the type of industry and environmental conditions. Evaluation methods should be revised in such a way that they can consider all aspects of activities and also can include the mutual effect of risks on each other, both positively and negatively, in risk calculations (RPN). The purpose of the study, on the topic of risk identification and assessment, is to review the risk assessment indicators and environmental aspects in the HSE-MS management system for more adaptation of the risk identification and assessment method to the target industry. In the following, to solve the problems raised, we perform risk assessment calculations (RPN) due to the ability of the quality function development (QFD) method to solve these problems, using the fuzzy QFD method. The tool used in the fuzzy QFD method is the fuzzy House of Quality (HOQ). Due to the use of fuzzy logic, fuzzy quality house solves the lack of transparency in language variables and makes risk calculations closer to reality and considers the mutual effect of risks (negatively and positively) in risk assessment (RPN) and enters all risks into the matrix at the same time identifies the most important environmental risks and aspects and identify and analyze the most important indicators.

2. Literature review

There are more than 70 types of methods to evaluate occupational health and safety risks and environmental aspects. Among these methods are the operation and risk study method, the what if analysis method? preliminary risk analysis (PHA), which can be used depending on the type of industry and environmental conditions. Also, multi-indicator decision-making methods such as AHP, SAW, ELECTRE and dynamic planning methods, fuzzy expert systems and neural network algorithms have been used to evaluate occupational safety and health risks and aspects Environment. To decide on how to allocate the cost, training and preventive measures in the discussion of HSE safety management in construction projects, one of the key parts is the ranking of high-risk risks of these projects. After evaluating the risks and ranking them, it is possible to scientifically and accurately prevent the occurrence of risks by focusing resources on the priority risks that cause delays in the project reaching its goals. After identifying the first risks of the jobs, the TOPSIS multi-criteria decision-making method was used to determine the first few risks of the mentioned projects (Latifi and Ravanshadnia, 2018). In their article (Rashtchian et al., 2019), Rashtachian and colleagues used multi-choice decision-making methods for the risk assessment process. They also present an attitude based on the fact that risk assessment is done in order to direct resources and management plans. Therefore, in the risks under study, options have been considered based on the common indicators of risk calculation and evaluation with Elekter and Saw methods from the total of multiple decision-making methods. The next case is the use of trapezoidal fuzzy AHP to calculate work safety and the initial warning rate in hot and humid environments by Mr. Zang (Zang et al., 2011). Hot and humid workshops exist in many industries, and the workers in these workshops are exposed to the risk of boredom and distraction, which reduces productivity and safety problems. The hierarchical method of trapezoidal phase has been used to calculate the safety factor of work in hot and humid environments. Trapezoidal fuzzy numbers have been used to eliminate the ambiguity of the discussed data in the decision-making process. Azadeh and colleagues (Azadeh and Nikfroz, 2008) refer to this issue in their article, where HSEE includes environment, safety, health and ergonomics. The indicators and standards related to the above factors have been determined, and then the integration of data and their entry into the fuzzy expert system has been proposed. Finally, the fuzzy expert system determines whether the data is within the standard range or not. If they are not within the standard range, it will be reported to the HSEE team, and this team will determine a corrective way and fix the risk, and these steps will be repeated by the expert system until all the risks are within the standard range. Azadeh et al. (Azadeh et al., 2008) used the continuous ANN algorithm (artificial neural network algorithm) to evaluate and improve job satisfaction in terms of HSEE in a system. Further, the review of articles showed that fuzzy QFD has not been used for risk assessment. Fuzzy QFD has been used more for product design, listening to the customer's voice and creating production agility, etc.

3. Methodology

In this research, we investigated the methods of evaluating occupational health and safety risks and environmental aspects based on the FMEA model. Also, we study the factors causing the difference between the evaluation results and the prioritization of these parameters to the needs of customers (workers and legal guardians) using fuzzy logic and House of Quality (HOQ). In the continuation of the research, we will first introduce the extension of QFD performance and the technique used in QFD is House of Quality (HOQ). Fuzzy Quality House will be used to evaluate safety risks and environmental aspects. Using the fuzzy quality house, risks and indicators will be prioritized. Triangular fuzzy numbers are used to show the relationship between risks and indicators. Finally, the

applicability and effectiveness of the method will be shown with a case study (Barite Plateau Group of Iran).In industry, HSE is derived from three elements of health, safety and environment and is known as the health, safety and environment management system (Figure 1).The HSE-MS standard is a combination of two occupational and environmental safety and health standards. One of the reasons for the formation of the IMS system is to balance the elements of environment, safety and health and quality, which is beautifully done in the HSE standard regarding safety, health and environment, so that no distinction is made between these elements. This standard has 7 clauses that pay special attention to the issues of personnel training, evaluation of contractors, evaluation of the level of risk tolerance of risks and the existence of emergency plans in the organization.

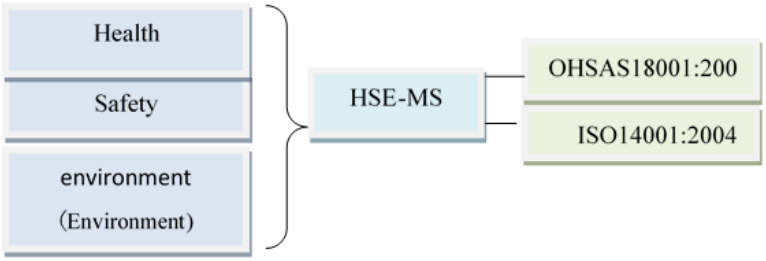


Figure1. formation stages and components of the quality management system

3.1. Risk assessment

In order to evaluate the risks and consequences arising from the occurrence of hazards, implementation methods should be created according to the probability of occurrence and the severity of the consequences of the events based on the criteria determined for the society, environment and assets. Also, these methods should be established and implemented for society, the environment and assets. It should be noted that none of the evaluation methods are 100% reliable and can have different results. Therefore, formal techniques and techniques of risk assessment should include a combination of opinions of experienced personnel, regulatory organizations and society. The process of evaluating the risk (risks) caused by the risk (risks), considering the adequacy of existing controls and deciding whether the risk (risks) is acceptable or not?

3.2. Expanding product quality function (QFD)

Expanding product quality performance emerged as a simple concept from the heart of quality engineering for product development in the late 1960s. In Japan, the statistical quality control method (the method imported to Japan from America) was the only system for quality control. Between 1960 and 1965, after the consultation of the Japanese with the best professors of quality, namely Juran, Feigenbaum, and especially Ishikawa and Deming, the concept of comprehensive quality control appeared, which quickly replaced the statistical quality control method. In 1966, Akao and Oshiomi presented quality assurance tables for the first time at the Bridgestone Rubber Factory. In these tables, in fact, quality was concretely interpreted by production factors, which were the main foundation of the QFD method. Then, design and value engineering perspectives were added to QFD. Since 1987, QFD has been well received. Currently, QFD is not used for quality control, it is used more for design management and product development. The development of quality performance is a systematic method for identifying, prioritizing and focusing on the expectations of the stakeholders, which guides the organization in the direction of gaining the satisfaction of its customers and at the same time increasing competitive power.Some of the advantages of using QFD are customer orientation, reducing execution time, preparing documents and gathering knowledge in the organization. Some of the prerequisites and limitations of QFD are the commitment of different parts at high and middle levels of management. The amount of work done at the beginning of the project is more compared to other design methods. But the group members may not have the experience and skills of group work (Razmi, 2007).

3.3. Triangular fuzzy numbers

Definition of triangular fuzzy numbers: suppose Ñ=(m, α, β)L, then Ñ is a triangular fuzzy number (T.F.N), if the relation (1) holds:

$$L(X) = R(X) = \begin{cases} 1 - X & 0 \le x \le 1 \\ 0 & \text{et} \end{cases} \quad \text{relationship (1)}$$

3.4. Sorting fuzzy numbers

Various methods have been provided to determine the order of fuzzy numbers. One of the methods is explained here. In this method, three criteria are presented, which must be applied sequentially in order to sort all the fuzzy numbers. That is, if some numbers are not sorted using the first criterion, then the second and third criteria will be

used, respectively. The first criterion for sorting fuzzy numbers (enclosed surface). The second criterion for sorting fuzzy numbers (mode). The third criterion for sorting fuzzy numbers (domain) (Azar and Faraji, 2007).

3.5. Research findings

One of the main factors in the establishment, monitoring and maintenance of the HSE-MS management system is the assessment of safety risks and environmental aspects. The fuzzy QFD method, with the ability to consider the mutual effect of risks and criteria, as well as the prioritization of risks and criteria, is presented with fuzzy logic and its simplicity and comprehensiveness in calculations with the steps of Figure2:

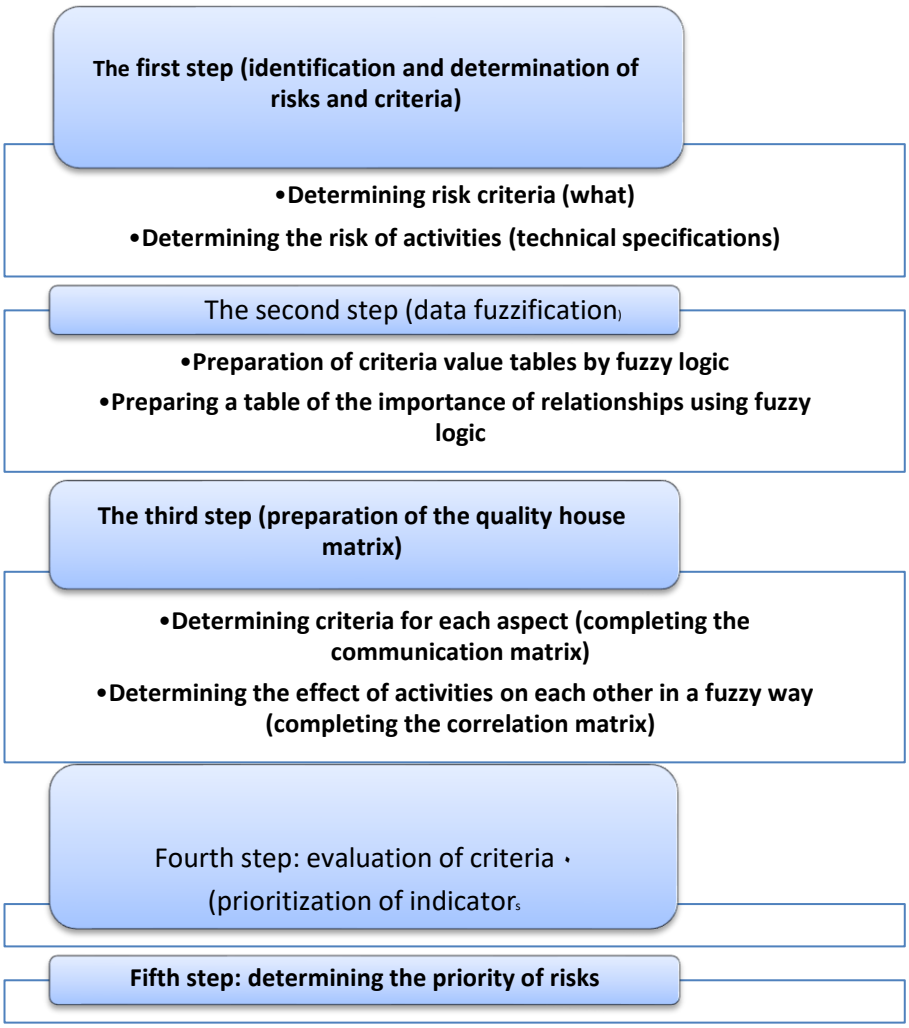


Figure2. Flow chart of the proposed model aspects and health and safety risks and determining standards

3.5.1. Identification of environmental aspects and safety and health risks

risks: In order to identify and evaluate risks and hazards, it is necessary to determine the inputs of the process of hazard identification and risk assessment. These items include legal requirements and other occupational health and safety requirements, occupational health and safety policy, accident analysis records, quasi accidents and occupational diseases, non-conformities. Also, the results of the occupational health and safety management system audit or the results of the "initial status review" report, consultation and interviews with employees, supervisors and managers, information of similar organizations, information on processes, activities and facilities of the work environment.In this section, 10 experts, experts, supervisors and workers are invited to cooperate in determining environmental risks and aspects of the HSE committee. By using a questionnaire and according to the laws and regulations of the labor and social security departments and the work environment, and by using the methods of observation, interview, and reviewing the records of incidents that occurred during the past period, the risks and risks of each unit are identified. These risks become risks with occupational health and safety laws and regulations. In this way, the risks of the activities of each unit or process are identified. The causes of occupational health and safety hazards and risks and the consequences are recorded in the form of identification and evaluation and control

of occupational health and safety risks, as well as environmental aspects in the form of identification and evaluation of environmental aspects.

3.5.2. Determining the standards

the methods of assessing and identifying risk and environmental aspects in the HSE-MS management system need to be reviewed and adapted to the industry due to their generality. In order to take into account, the general sensitivity of society, loss of mineral materials, characteristics of pollutants and dimensions of risk expansion and aspects, the following indicators were defined and used for the first time.

3.5.2.1. The potential of public protest

The potential of public protest: It is a parameter to evaluate the sensitivity of the general society to the consequences arising from environmental aspects. In terms of air pollution and waste, it is measured with a factor of 3 and water pollution with a factor of 1

3.5.2.2. Loss of materials

It is a parameter that is used for the aspects that are related to the consequences of water, soil and air pollution with the loss of materials. In cases where material loss is determined, the coefficient is 2 and otherwise zero.

3.5.2.3. Positive aspects

In most cases of risk assessment, only the negative aspects of activities are calculated. The positive aspects of activities such as creating green space, purifying water used by the industry for agricultural activities and creating employment and solving the problem of unemployment and education are not calculated. We intend to include this category in the risk assessment calculations by using the quality of house and taking these things into consideration in determining the control measures.

3.5.2.4. Pollutant property

The pollutant property means the origin of its effect on the environment including soil, air, water and sound.

3.5.2.5. Dimensions (in the risk assessment method)

Dimensions in the risk assessment method are defined as the number of workers exposed to risk.
According to the review and proposed criteria in the HSE method and other risk assessment methods and experts' opinions, the criteria in the environmental aspects assessment section include the following. Probability of occurrence, probability of detection, dimensions, consequences, characteristics of pollutants and potential of public protest and in the health and safety risk assessment section including probability of occurrence, probability of detection, dimensions (number of exposed workers). The second step - data fuzzification (determining relational fuzzy tables and risk criteria level fuzzy tables): Triangular fuzzy numbers have been used for data fuzzification. The criteria of intensity, probability of occurrence, detection probability, dimensions, characteristics (water, air, soil) are determined as triangular fuzzy numbers. Step 3 - Preparation of fuzzy quality house matrix: In the proposed quality house, criteria are entered in the first column and risks are entered in the first row. The roof of the quality house is a correlation matrix that is used to determine all our internal connections between environmental aspects of activities and risks. In some cases, the increase or decrease of some risks and aspects have an increasing or decreasing effect. Inside the quality house, there is a relationship matrix. The correlation matrix is used to show the degree of correlation between each risk description and criteria. The correlation matrix and the correlation matrix are completed according to the relationship between indicators and the relationship between indicators and risks. Step 4 - Evaluation of criteria: according to the opinion of experts and workers, the level of importance, the current state of the organization, and the plan of the organization have been determined for each criterion (index). The improvement ratio and correction factor, absolute weight and relative weight are determined according to relations (2) and (3). The absolute weight is obtained by dividing each of the relative weights by the sum of the relative weights. Degree of importance of the index: existing status of the organization, organization plan, : improvement ratio : correction coefficient : absolute weight

relationship (2)
$$\tilde{D} = \frac{\tilde{C}}{\tilde{B}}$$

relationship (3)
$$\tilde{F} = \tilde{A} \otimes \tilde{D} \otimes \tilde{E}$$

In the case of evaluating the criteria of environmental aspects, the importance of damage to water, soil and air will be determined. The priority obtained in the evaluation section of risk criteria can indicate the level of attention and importance of organizations and workers to the severity, probability of occurrence and probability of discovery and dimensions of risks. The obtained priorities can be used in prioritizing control measures to reduce risk and environmental aspects. In this way, the control measures that reduce the first priority of the criteria are placed in the first priority, and the control measures that reduce the second and third priorities are placed in the next priority.

Step 5 - Risk prioritization: To determine the safety and occupational health risk priority of each activity in the quality house, we use relationships (4) and (5).

severity of risk, probability of occurrence, probability of detection, amount of contact: number of risks and aspects of activities: indicating the relationship between risks: fuzzy priority number

relationship (4)

$$RPN = (\tilde{S} \otimes \tilde{P}) \otimes (\tilde{D} \otimes \tilde{E})$$

relationship (5)

$$\tilde{S}_j = RPN_j \oplus \sum_{k=1}^{n} T_{jk} \otimes RPN_k \qquad j = 1 \ldots n$$

In the method of evaluating the environmental aspects of the activities, the risk intensity ($\tilde{S}$) is obtained from the sum of the waste of materials, the potential of public objection and the characteristic. After calculating the risk number related to each of the options, because these numbers are fuzzy, it is necessary to determine the magnitude of each of the fuzzy numbers with the mentioned methods. The criteria for sorting fuzzy numbers are the bounded surface method, mode method, and domain method, and fuzzy numbers should be sorted by these methods in order to get the priority of risks. If we show the triangular fuzzy numbers in the form, the enclosed area is calculated from equation (6).

C_J : : indicating the priority of risk

relationship (6)

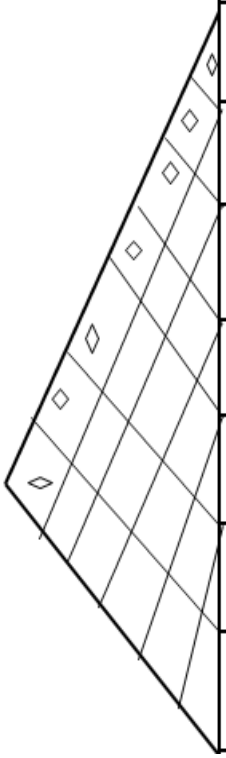
$$C_J = \frac{(1 + 2m + u)}{4}$$

If the priority of the risks is not achieved with the enclosed surface method, we can use the mode and average methods respectively.

4. A case study

Barit Plateau Company of Iran, the first factory for the production of industrial-mineral powders for the purpose of producing the raw materials needed for drilling mud of oil wells, was built and put into operation in 1338 in Salafchagan intersection with an approximate capacity of ten thousand tons per year. The products of this company mainly include barite powder and bentonite powder according to OCMA and API standards, as well as calcium carbonate and iron oxide powder. Iran's Barite Plateau Company is also directly active in the field of exploration and extraction from barite, bentonite and hematite mines under its cover and is responsible for extracting and transporting mineral materials to factories for processing using its own fleet. In order to evaluate the safety risks and environmental aspects of Barit Plateau Iran Company of Parandak factories, the fuzzy QFD model was used and according to the quality house (table (1,2)) the risk calculations of the welding sector were done.

Table1. Safety risk calculations using the quality table



Description of the activity	effect intensity	Probability of discovery	probability of occurrence	Dimensions	relative weight	Risk level	Risk priority
Drilling-breaking-throwing	7.2	5.2	5.2	5.2	489.6	406.6	366.7
	65	4.5	4.5	4.5	426	489.6	
	6	4	4	4	126	81	
Cutting work - explosion	10	2.5	3.2	1.7	187.5	554.1	491.7
	9.5	2.5	2.5	1.6	573.1	587.7	
	9	2	2	1.4	126	111	
Work cut - burn	6.2	3.2	7.2	7.2	312.2	280.9	291
	5.5	2.5	6.5	6.5	380.9	375	
	5	2	6	6	57	29	
Welding - Varicose veins	6.2	5.2	2.2	2.2	69.4	28.25	40.5
	5.5	4.5	1.5	1.5	74.25	69.4	
	5	4	1	1	10	-5	
Welding - burns	6.2	3.2	7.2	7.2	314.5	313	230
	5.5	5	6.5	5	272	273	
	5	2	6	6	60	61.4	
Welding work - dermatitis	7.2	6.2	3.2	3.2	174	140	127
	6.5	6.5	2.5	2.5	159	174	
	6	6	2	2	36	21	
Electrocution welding	6.2	2.1	5.2	5.2	56.5	68.4	34
	5.5	1.5	14.5	4.5	47.4	47.25	
	5	1	4	4	10	10	

Table 2. Safety risk calculations using the quality table

	effect intensity	Probability of discover	probability of occurrence	Dimensions	relative weight
Improvement ratio	1	1	.5	1	
	1	7	.35	.7	
	.7	.5	1	5	
Current status of the organization	.5	.5	1	.5	
	.35	.35	1	.35	
	.3	.3	.7	.3	
Correction factor	.3	3.67	.93	.93	
	.01	2.83	.65	.65	
	.001	1	.3	.3	
	1.5	1	1.5	1.5	
relative weight	3.47	17	.35	.35	.32
	.19	.06	.14	.14	.12
	.023	.005	67.4	.017	.016
Priority of indicators	21.27	7.6	15.73	15.73	14.48

After performing risk assessment calculations using the fuzzy quality house and the usual risk assessment method, the priority of the risks of the welding sector with the fuzzy QFD method and the usual risk assessment method is shown in table (3).

Table 3. Comparison of welding risk priority with two common methods of risk assessment and fuzzy QFD method

Fuzzy QFD method			**The usual method of risk assessment**		
	Description of the activity	priority		Description of the activity	**priority**
491.7	Cutting, oil contact with cutting capsule hose, explosion	1	35	Welding, radiation, lightning eyes	**1**
366.7	Drilling, breaking and throwing drill	2	30	Improper sitting - varicose veins	**2**
291	Gas cutting - burns	3	28	Molten material throwing welding	**3**
230	Molten material throwing welding	4	28	Welding, ion radiation, skin contact	**4**
127	Welding, ion radiation, skin contact	5	25	Gas cutting - burns	**5**
40.5	Improper sitting - varicose veins	6	25	Drilling, breaking and throwing drill	**6**
34	Welding - radiation - lightning eyes	7	16	Cutting, oil contact with cutting capsule hose, explosion	**7**

By examining the table (1) and the obtained priorities for safety risks, it can be seen that there are significant differences between the priorities in the two methods. In the risk assessment method carried out in Iran's Barit Plateau Company to obtain the HSE-MS standard, the dimensions (number of exposed workers) and the probability of detection were not taken into consideration. Also, not using fuzzy logic and mutual effects of risks and aspects have been effective in this prioritization difference. If in the fuzzy QFD method, dimensions, probability of detection are considered as criteria, in addition to the probability of occurrence and intensity, and analyzes have been done with the fuzzy quality house method. In this analytical method, the mutual effects of risks are considered and the criteria are prioritized. Based on this, the criterion of the severity of the effect (such as the percentage of death) is the first priority, the probability of accidents is the second priority, the dimensions (the number of workers at risk) is the third priority, and the probability of detection is the fourth priority. The results of prioritizing criteria can be used in prioritizing control measures to control and reduce risks. In such a way, that the actions that reduce the intensity of the effect are the first priority and the actions that reduce other criteria are priority. The prioritization of environmental aspects with two fuzzy QFD methods and the usual method is in the form of table (3). In the usual method of risk assessment, the indicators are the intensity of the effect and the probability of occurrence, and in the fuzzy QFD method, the intensity of the effect (property (soil, air, water), public objection potential, waste of materials), probability of occurrence, probability of detection and dimensions. The reason for the difference in prioritizing the two methods in table (4) is the factors mentioned in the analysis of the difference mentioned in the safety risk assessment. According to the obtained priorities, the company should create and establish implementation methods for selecting, evaluating and implementing measures to reduce risk and the effects of risks. The implementation of control measures will be done depending on the priority of risks and aspects, other parameters, including the financial power of the company and the priority of the indicators obtained in the fuzzy QFD table. For example, at the first opportunity, the company should modify the dust filter system. In this research, one of the indicators of prioritization of control measures has been obtained. In the correction of dust risk, public protest is the first priority. The control measure that will lower public protest will be given first priority.

Table 4. comparison of the priority of environmental aspects obtained by the usual risk assessment method and the fuzzy QFD method

The usual evaluation method			Fuzzy QFD method		
RPN	Environmental aspect	priority	RPN	Environmental aspect	priority
35	Mill output heat	1	1456	Mill output dust	**1**
35	Oiling vehicles	2	899.7	Loss of minerals	**2**
15	oil splash	3	752	Forklift exhaust gases	**3**
15	Forklift exhaust gases	4	513	Mill output heat	**4**
12	Noise	5	509	Kitchen waste	**5**
10	Groundwater pollution	6	393.5	Noise	**6**
10	Mill output dust	7	393	The waste of the production process	**7**
8	The waste of the production process	8	265.3	Oiling vehicles	**8**
8	Kitchen waste	9	265	Groundwater pollution	**9**
4	Loss of minerals	10	106.8	Oil splash due to replacement	**10**

Investigating the performance of the normal risk assessment method in comparison with the fuzzy QFD method and the validity and reliability test of questionnaires and results, with the help of consultation with experts and calculation of Cronbach's coefficient. By designing a questionnaire, ten experts, managers and workers of Iran's Barit Plateau Company were asked to express their opinions about the performance of the two methods. This questionnaire was scored based on the Likert scale. On the phrase, I completely agree. number 5, I agree, score 4, I have no opinion, score 3, I disagree, score 2, I completely disagree, score 1. The declared opinions of the experts were analyzed based on the spectrum using SPSS version 19 software. The number of designed questions was 21, based on SPSS analysis. One question was removed due to lack of variance and one question was removed due to lowering Cronbach's alpha. The results obtained from SPSS software are shown in Table (5), Table (6). The total average obtained according to table (5) is 83.4. The average of 83.4 percent of the questionnaire confirms that the experts and managers completely agree with the excellent performance of the fuzzy QFD method in comparison with the usual risk assessment method. The standard Cronbach's alpha obtained for the whole questionnaire is 0.808 (number one indicates full reliability). The results of this study show that the investigated questionnaire has the necessary validity and reliability and is a suitable tool for investigating the performance of the usual risk assessment method in comparison with the fuzzy QFD method.

Table 5. Cronbach's alpha obtained for the questionnaire

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.799	.808	19

Table 6. mean and deviation of the questionnaire

Mean	Variance	Std. Deviation	N of Items
83.40	60.267	7.763	19

5. Conclusion

Despite the fact that extensive technological advances have been very effective in increasing the efficiency and speed of doing things, studies show that the advances themselves have become the cause of new potential and actual risks and dangers. Therefore, it is necessary to create, implement and maintain standards to increase safety and preserve and protect the environment. Among these standards is the standard of safety, health and environment management (HSE-MS). In this management system, in order to achieve safety, health and environmental protection goals, it is necessary to foresee and implement a series of corrective and control measures. Sometimes these measures are limited in terms of cost and technology for companies and organizations. For this reason, companies and organizations want to implement control measures. In this regard, the resources and time available to them are limited. Therefore, there is a great need to prioritize control measures. There are many methods for evaluating and prioritizing environmental risks and aspects. Most of these methods are useful and effective, but they have advantages and disadvantages. Therefore, one of the methods can be chosen depending on the conditions. Most of the usual methods of risk assessment do not pay attention to the mutual effect of risks and evaluate risks and environmental aspects separately. In these evaluation methods, criteria are not prioritized either. The used multi-criteria decision-making methods also have computational complexity and should be performed by experts.The proposed QFD risk assessment method, while having the ability to consider the mutual effect of risks and simplicity in calculations, resolves the ambiguity in determining the relationship between risks and criteria. It also deals with the prioritization of environmental risks and aspects and standards with more precision and accuracy.By examining the results of two parts of welding safety risk assessment in table (2) and the environmental aspects of Parandak factories in table (3), the priorities obtained for the risks have tangible differences and can be considered. The investigation shows that the causes of this difference are the improvement and revision done in the risk assessment and indicators section, as well as the capability of the fuzzy QFD method. As observed in the case study section, in the usual method of risk assessment, only two factors of severity and probability of occurrence are considered as indicators. But in the study of indicators; intensity (which includes characteristics (water, soil, air), potential for public protest and waste of materials), probability of occurrence, probability of detection and dimensions (extent and number of exposed people). Also, in the fuzzy QFD method, the mutual effects of risks are considered and the criteria are prioritized. Based on this, the criterion of the severity of the effect (such as the percentage of death) is the first priority, the probability of accidents is the second priority, the dimensions (the number of exposed workers) is the third priority, and the probability of detection is the fourth priority. The results of prioritizing criteria can be used in prioritizing control measures to control and reduce risks. In such a way that the actions that reduce the intensity of the effect are the first priority and the actions that reduce other criteria are the next priority. The total average obtained for the questionnaire, according to table (4), is 83.4. The average of 83.4 percent of the questionnaire confirms that the experts and managers completely agree with the excellent performance of the fuzzy QFD method in comparison with the usual risk assessment method. The standard Cronbach's alpha obtained for the whole questionnaire is 0.808. The results of this study show that the investigated questionnaire has the necessary validity and reliability. It is also a suitable tool for investigating the performance of the usual risk assessment method in comparison with the fuzzy QFD method.In two fuzzy QFD methods and the usual risk assessment method, numerical tables of effect intensity, probability of occurrence, dimensions, contact amount and other criteria are determined according to the opinion of experts and specialists of industrial and service units. In the following, the amount of acceptable RPN risk is also determined by the same group. __ Because the RPN calculated by different expert groups may not be the same, it is suggested that standard tables be compiled and prepared for this purpose so that the calculated RPN is standardized.In most of the conducted studies, the focus is on determining the priority of risks. If after determining the risks to determine the control measures for each risk, there are many options for control measures. In this research, one factor, the prioritization of indicators, was determined for the prioritization of actions. With further studies, the fuzzy QFD method can be developed for this purpose and more criteria can be considered in prioritizing control measures with the fuzzy QFD method.

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