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Assessment of Emergency Response Preparedness in Power Plant Using FEMA Method (Case Study: South Isfahan Power Plant)

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ABSTRACT

Introduction: The aim of this study was to identify all activities to be sufficiently prepared for emergencies in the power plant industries using the method of the Federal Crisis Management Organization in the south Isfahan power plant.

Materials and Methods: In this research, a checklist tool of 117 questions in 9 sections based on the FEMA method has been used. Checklists were localized. To check the face and content validity of the checklists, the opinions of three technical experts were used, and to check the reliability of the research subjects, the test-retest test was used, and to measure the reliability of the checklists, Cronbach's alpha coefficient was used with an emphasis on internal correlation. The obtained alpha coefficient was 0.76. Data were analyzed using SPSS software.

Results: The results showed that the power plant preparedness for general emergencies is 77.5%, winter storms and extreme cold 80%, storm 73.33%, overheating 70%, chemical storage 88.57%, earthquake 65%, Fire and explosion is 87%, flood 63.33%, and lightning 92%. The highest level of preparedness with 92% was related to the lightning checklist and the lowest level of readiness with 63.33% was related to floods.

Conclusion: In general, despite the differences in the readiness of the power plant against various accidents, the average level of preparedness for all accidents is higher than average. However, a number of appropriate measures must be taken in each area and the level of preparedness must be increased in cases such as fires and explosions.

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Introduction

Although humans' great progress over the past centuries has markedly increased their power to prevent and respond to disasters and accidents, they are not yet able to fully control such events [1]. Each catastrophic event is a reminder of the importance of preparedness to respond effectively in the event of an emergency. For example, the methyl isocyanate gas leak (Bhopal, India), the explosion of the Chernobyl reactor in Ukraine, the explosion of the Pasadena petrochemical super vapor, and several other cases [2]. Global experience and review of events and disasters that have been experienced in recent years in Iran and the world show that most of the damage and loss is due to mismanagement in the systems that are involved.

They know how to respond to emergencies [3]. Many catastrophes that occur show the importance of effective preparedness and response in the event of an emergency. For example, the methyl isocyanate gas leak (Bhopal, India), the explosion of the Chernobyl reactor in Ukraine, the explosion of the Pasadena petrochemical super vapor, and several other cases [4]. Crisis management is a process that involves evaluating the signs of a process crisis and requires prevention and implementation, which is used to overcome the crisis to reduce harm. Crisis management can be described as a systematic effort by the members of the organization along with external stakeholders to prevent crises or its effective management at the time of occurrence [5]. In the new age and the third millennium, crises have become an inseparable reality from the internal nature of organizations. Crises are caused by natural and unnatural events and factors and cause damage to a group or human society. Crisis management requires experience, preparedness, skill, speed of action, intelligence, and innovation more than anything else to deal with sudden and unexpected situations. Crisis management is the process of planning and performance that by systematically observing and reviewing crises, seeks to find a tool to reduce the effects of the crisis. Scientists agree that in times of crisis, the greatest pressure is placed on society and the managers of the organization. Therefore, managers need to be prepared and develop their abilities to properly deal with the crisis [6]. Crisis assessment is an important part of the crisis management process and related research. Like any other management area, crisis management can considerably benefit from an accurate understanding of the crisis to help and guide it to control the incident or make it manageable through detailed dissection and analysis of the problem [7]. Disaster risk reduction and management is a regular process aimed at maximizing the organizational and executive capacities and the skills that can minimize the consequences of disasters [8]. Dynamic events, time pressure, high risk, and poor training can have devastating impacts on the performance of a person involved in emergency management [9]. Individual cognitive orientations, teamwork errors, lack of explicit coordination, and communication problems are uncommon in emergencies [10]. To ensure effective control over emergencies and crises, organizations need an emergency management system in place to conduct and coordinate prevention, effect mitigation, preparedness, response, and recovery tasks and duties [11]. The most important link in this chain is preparedness [12]. Indeed, the most important principle of crisis management is to anticipate and prepare for the occurrence of crises. The more attention given to the pre-crisis preparation tasks, the lower the costs and damages sustained during and after the crisis. Hence, managers must make sure that all parts of the organization are equipped with the information systems needed to prepare for crises [13]. Given its size and climatic diversity, Iran is among the world's top ten most disaster-prone countries [8,14].

There are always potential risks in industries and process facilities, and if they are actualized, they can cause life-threatening, financial, and environmental damage, as well as damage to the reputation of an organization at the national and international levels. The Fukushima accident that occurred in 2011 caused a severe shock to the body of the nuclear power industry and seriously damaged the level of public confidence in the safety of these facilities [15]. An example of a crisis that has occurred in Iran, the fire in the 17-story Plasco tower in 2016, which was a great disaster [16]. Among the various natural hazards that occur on the surface of the earth, the movements caused by earthquakes undoubtedly have the greatest destructive effect on the regions [17]. A study conducted on the safety and disaster preparedness of Ilam University of Medical Sciences hospitals in 2013 showed that in all the studied hospitals there was no operational plan to respond to internal and external hazards and in the event of a major accident, these hospitals will face a serious problem [18]. Shiwaku conducted a study on the level of resilience of Japanese schools in the face of emergencies and stressed the need to strengthen the link between education and society and to involve more designers in the emergency planning process [19]. The need to pay attention to potential emergency management is the need of all organizations with social interactions. This also applies to all units of the electric power industry including power plants. In the power plant industry, despite the strong and complex design of the system and the high reliability of the equipment, many small and large accidents occur. Considering the paucity of studies on the preparedness of Iranian power plants to respond to potential emergencies and the history of emergencies in this sector, this study attempted to identify and evaluate all activities to be sufficiently prepared for emergencies and provide practical solutions to the activities whereby these plants can become sufficiently prepared for emergencies and also to provide practical solutions to help them achieve this level of preparedness to minimize losses and damages in emergencies using the FEMA method. Due to the lack of current studies to assess the level of preparedness of the country's power plants against possible emergencies and the history of emergencies in this industry, this study aims to identify and evaluate all activities to be sufficiently prepared for emergencies and provide practical solutions. And is designed to achieve adequate preparedness and minimize losses and damage in critical situations in the power plant industry using the method of the Federal Crisis Management Organization in the power plant south of Isfahan. This study involved measuring the preparedness of this power plant to respond to potential emergency and crisis situations, identifying the related weaknesses and shortcomings, and creating a list of measures that must be taken to reduce vulnerability and ensure effective emergency management in this unit.

Materials and Methods

Since this study is done to improve behaviors, methods, tools, equipment, etc., it is based on applied purpose and is descriptive in terms of nature and method of research. This case study was conducted in 2020 on the South Isfahan power plant in Isfahan, Iran. The tool used in the study was a 9-part questionnaire designed by the researchers based on the checklists of the United States Federal Emergency Management Agency (FEMA). Since this was the first study of its kind to be conducted in Iran, therefore there were no readymade localized checklists available for the purpose of the study, necessary steps were taken to prepare standard checklists in a localized manner by the researcher. For this purpose, the FEMA guidelines were reviewed and the items and questions related to each potential emergency situation were extracted and inserted in a series of draft checklists. These checklists consisted of 24 questions about general emergencies, 8 questions about earthquakes, 12 questions about flooding, 5 questions about lightning, 8 questions about winter storm/extreme cold, 6 questions about storms, 10 questions about extreme heat, 21 questions about chemical stockpile hazards, and 23 questions about fire/explosion.

To check the validity of the checklists, the opinions of technical experts were used, and the checklists were reviewed in a formal and content manner, and the questions that received sufficient scores were kept in the questionnaire. For this purpose, two methods, quantitative and qualitative, have been considered. In the qualitative study, with the help of 3 experts related to the subject under discussion, statistical and epidemiological experts, individual questions were examined. Also, with the help of English and Persian language experts, the existence of inadequacies in the meanings of the words was examined and if there was a problem, the necessary changes were applied in the checklists. For quantitative analysis, a questionnaire with a five-part Likert scale from very weak to very strong (1-5) was prepared. Then the questionnaire was given to the sample to determine face validity. Then the score of each question was calculated. A score of more than 1.5 was a sign that the question was appropriate. Initially, the number of questions was 120, after completing the questionnaire, 4 questions were removed from the total questions due to low scores (less than 1.5) and finally, 116 questions remained in the questionnaire.

To evaluate the reliability of the checklists, Cronbach's alpha reliability method was used with an emphasis on internal correlation and the obtained alpha coefficient was equal to 0.76. The finalized checklists were completed by the technicians with knowledge about emergencies in the area of interest. In this phase, the research population comprised of specialist technicians employed in the South Isfahan power plant who had over 10 years of experience and whose work was susceptible to emergency situations. Overall, the plant had 64 personnel, who were either day workers or shift workers. In order to determine the sample size according to the nature of the checklists and the specialization needed for some of its questions, a team of 20 experts with relevant qualifications was formed to complete the checklists was formed. The reliability of these individuals was examined by conducting a test-retest. The checklist was distributed among these 25 people twice, with a one-month difference. Based on the results, 5 people were removed from the sample, leaving 20 participants. All employees participated in the study with consent. The final questionnaire was completed by the 20 people whose reliability was previously confirmed by test-retest. To ensure uniform conditions and eliminate interfering factors, all individuals were invited to attend for completing the checklists.

After collecting the questionnaires from the 20 participants, the provided data were extracted and analyzed. Then, using techniques based on descriptive statistics and inferential statistics, the information extracted from the dissertation was analyzed using SPSS 22. First, checklists were prepared and completed to identify weaknesses and drawbacks in each of the emergencies, and potential hazards arising from these weaknesses were also identified. Then, according to the standard [MIL-STD-882E], the risk level of each risk was calculated in order to prioritize and provide proposed solutions for the risks. To estimate the level of risk according to the standard [MIL-STD-882E], the severity and probability for each risk were determined and then the final risk level for each risk was determined. Therefore, the probability, severity, and level of risk of each risk were determined through tables 1, 2, and 3 and placed in the prioritization tables for taking control measures for each emergency situation.

Table 1: Definition of different intensity levels according to the standard [MIL-STD-882E]

Description	Intensity level	Title
It can lead to one or more of the following consequences: death, permanent disability, significant irreversible environmental impact, a financial loss greater than or equal to $ 10 million.	1	Catastrophic
can lead to one or more of the following consequences: permanent relative disability, injury, or occupational disease that could result in the hospitalization of more than 3 staff members, significant reversible environmental effects, greater than or equal to financial losses of $ 1 million and less than $ 10 million.	2	Critical
It can lead to one or more of the following consequences: Injury or occupational disease with more than one-day loss, moderate reversible environmental effects, financial losses greater than or equal to $ 100,000, and less than $ 1 million.	3	Marginal
It can lead to one or more of the following consequences: Injury or occupational disease without a missed day, little reversible environmental impact, financial losses of less than $ 100,000.	4	Minor

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Table 2: Definition of different levels of probability of occurrence according to the standard [MIL-STD- 882E]

Description		Probability level	Title
It is experienced continuously	Most likely it happens often during the life of the system	A	Frequent
It happens frequently	It happens several times during the life of the system	B	Likely
It happens several times	Most likely it happens sometimes during the life of the system	C	Sometimes
Unlikely, but logically predictable.	Unlikely, but may occur during system life	D	Unlikely
Unlikely but possible	Very unlikely, it can be assumed over a lifetime The system may not be experienced	E	Improbable
Cannot occur. This level can be used when potential hazards are identified and then addressed.		F	Impossible

According to the risk matrix and [MIL-STD-882E] standard, it can be seen that in Table 7, red areas are at extremely high risk, orange areas at high risk, the yellow areas at medium risk, the green areas at low risk, and the blue zones indicate that the hazards are eliminated.

Table 3: Risk Matrix according to the standards of [MIL-STD-882E]

Intensity / Probability	Catastrophic (1)	Critical (2)	Marginal (3)	Minor (4)
(A)Frequent	Extreme	Extreme	Serious	Average
(B) Likely	Extreme	Extreme	Serious	Average
(C) Sometimes	Extreme	Serious	Average	Low
(D)Unlikely	Serious	Average	Average	Low
(E)Improbable	Average	Average	Average	Low
(F)Impossible	Removed			

To conduct the research, first a set of educational materials with chapters such as "Familiarity with possible accidents", "Census methods and use of personal protective equipment in the event of an accident", "How to cut off energy resources", "Organization emergency map", "First-aid kit location", "Communication tools", "Emergency exit routes", "Safe areas", etc. were presented to the study sample in the form of a face-to-face period during the accident. Then, in order to standardize the situation and eliminate the interfering factors, all individuals were invited to attend and take action to complete the checklists.

Ethical issue

The protocol of this study was approved by the Ethics Committee of Mashhad Academic Center for Education, Culture and Research with the registry code of IR.ACECR.JDM.REC.1399.013.

Results

Power plant preparedness for any emergency

After completing and collecting the completed checklists (Table 4) by 20 power plant experts, the obtained data were finally analyzed.

Table 4: Parts of the localized checklist

Checklist name	General	Winter storm/extreme cold	Storm	Flooding	Earthquake	Fire/ explosion	Chemical stockpile hazard	Extreme heat	Lightning
Number of questions	24	8	6	12	8	23	21	10	5

The results obtained from SPSS were used to create a "resultant" checklist for each considered emergency situation (Table 1). The responses were coded as none, poor, moderate, good, and excellent and were given scores of 1, 2, 3, 4, and 5 respectively. The results of the analysis conducted in SPSS are presented in table 5.

Table 5: Scores of the options chosen by the majority of respondents

Scores Checklist	None	Poor	Moderate	Good	Excellent	Total score
General	-	2	18	48	25	93
Winter storm/extreme cold	-	-	6	16	10	32
Storm	-	2	3	12	5	22
Extreme heat	-	4	6	20	5	35
Flooding	1	4	9	24	-	38
Earthquake	-	4	6	16	-	26
Chemical stockpile hazard	-	-	9	24	60	93
Fire/ explosion	-	4	-	36	60	100
Lightning	-	-	-	8	15	23

For each question in the checklist, a score was computed based on the scores of the responses given by the 20 participants. The maximum score that could be obtained for each questionnaire (the number of questions in the questionnaire multiplied by 5) was also determined. This maximum score for questionnaires of general emergencies with 24 questions, winter storm/extreme cold with 8 questions, storm with 6 questions, extreme heat with 10 questions, chemical stockpile hazards with 21 questions, earthquakes with 8 questions, fire/explosion with 23 questions, flooding with 12 questions and lightning with 5 questions were calculated to 120, 40, 30, 50, 105, 40, 115, 60 and 25, respectively (Table 6).

Table 6: Percentage of preparedness for each emergency

Checklist	Maximum possible score (b)	Earned score (a)	Percentage preparedness= $\frac{a}{b} \times 100$
General	120	93	77.5
Winter storm/extreme cold	40	32	80
Storm	30	22	73.33
Extreme heat	50	35	70
Chemical stockpile hazard	105	93	88.57
Earthquake	40	26	65
Fire/explosion	115	100	86.95
Flooding	60	38	63.33
Lightning	25	23	92

Figure 1 shows the results of the research, which includes the percentage of preparedness for each crisis. Additionally, it can be seen that the percentages of preparedness for general crises, winter storms and extreme cold, storms, overheating, chemical storage, earthquakes, fires and explosions, floods, and lightning are respectively 77.5, 80, 333.73, 70, 571.88, 65, 956.86, 333.63 and 92%. The highest level of readiness with 92% is related to the lightning checklist and the lowest level of readiness with 63.33% is related to floods. The results of the present study show that the preparedness of the power plant in the south of Isfahan in case of emergency is acceptable and the level of preparedness for each of the investigated accidents is more than 50%.

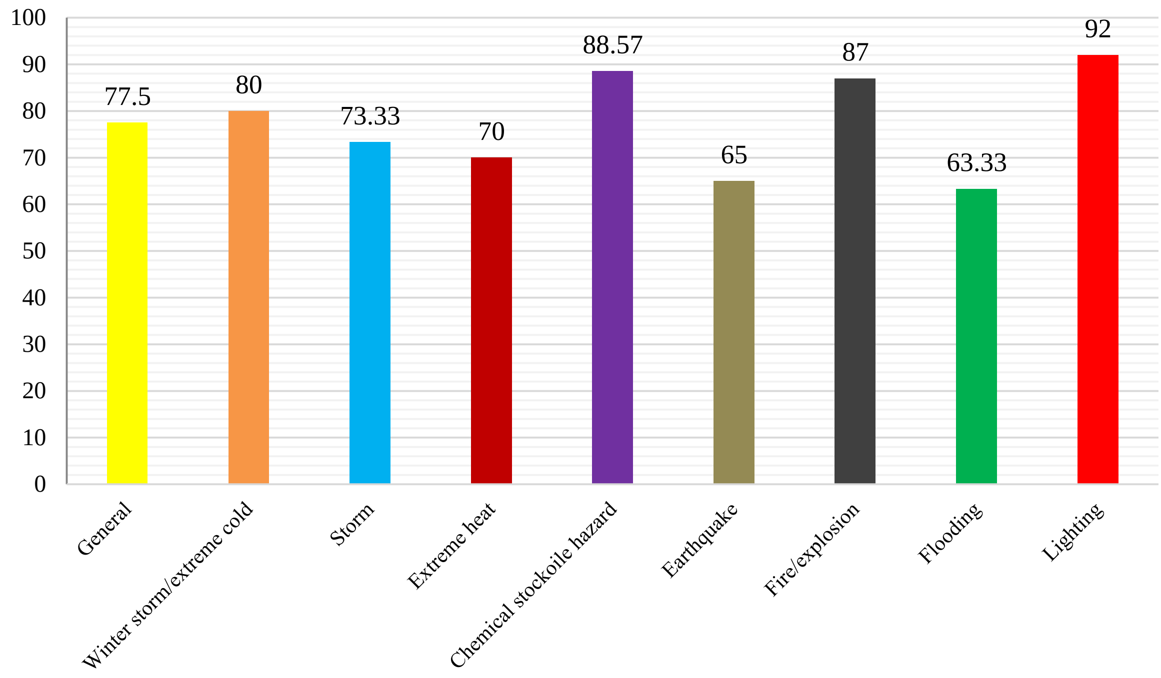

Figure 1: Percentage preparedness of south Isfahan power plant against each emergency

Strengths and weaknesses in the face of any emergency

In order to increase preparedness for any emergency, there should be an effort to empower the existing strengths and improve the weaknesses of the industry. Therefore, after the completion of the checklists, the industry's strengths and weaknesses were also identified. After extracting the data related to the identified weaknesses from each checklist, the potential risks arising from the existence of these weaknesses were also determined. Then, according to the standard [MIL-STD-882E], the risk level of each risk was calculated to prioritize and provide proposed solutions for the risks. The probability, severity, and level of risk of each risk were determined through tables 1, 2, and 3 and are included in the prioritization tables for taking control measures for each emergency situation. Table 7 gives an example of the prioritization of general emergency control measures. For example, using the information in table 7, general emergencies have 1 serious risk, 8 medium-level risks, and 2 low-level risks.

Table 7: Prioritizing the plant of control measures for the chemical stockpile checklist

Weaknesses	Question number in Table 4	Risk	Intensity	Probability	Risk	Suggestions
Lack of display of danger and accident hotspots in the maps	General (1)	Life and financial losses due to non-identification of danger centers	3	C	Moderate	Reviewing the maps and identifying the centers of the accident such as fire, explosion, and ...
Inefficiency in the working hours' system in case of total power plant cut	General (3)	Failure to conduct a proper census during accidents and as a result the possibility of not searching for injured people and timely relief	3	C	Moderate	Determining a suitable method for a census during accidents
Limiting the number of security personnel and the impossibility of using other groups	General (7)	Occurrence of further injuries and damages due to lack of timely assistance and impossibility of providing protection and security in emergencies	3	C	Moderate	Holding emergency assistance training classes for volunteer personnel from all industrial units, and increasing people
Need to perform maneuvers to familiarize and inform the staff	General (9)	Inability to apply the knowledge learned and react appropriately to events	2	C	Serious	Performing maneuvers to familiarize and inform all personnel
Lack of radio	General 10	Lack of timely information	4	D	Low	Providing radio and other necessary equipment
Need to conduct more training on emergencies such as earthquakes	General (13)	Personnel injuries due to lack of familiarity with the necessary measures in the event of various accidents	2	E	Moderate	Train personnel to be prepared and familiar with the necessary measures in all emergencies
Impossibility to continue the operation of the power plant in case of serious damage such as the fall of power towers or gas cut or damage to the main equipment of the units	General (16)	Economic losses for the organization	1	E	Moderate	Anticipation alternatives for emergencies
Relative observance of the grooming system in the	General (20)	Existence of obstacles in access routes, the impossibility of	3	C	Moderate	Requiring all personnel to use and fully implement the grooming system in

Weaknesses	Question number in Table 4	Risk	Intensity	Probability	Risk	Suggestions
workplace by personnel		timely access to emergency equipment such as fireboxes and capsules				the workplace
Non-segregation of any emergency in the instructions	General (21)	Lack of familiarity of personnel to take the necessary measures to prepare for various emergencies causes a lot of human and financial losses.	4	D	Low	Emergency preparedness instructions should be prepared and provided to staff in a variety of emergencies
Failure to develop instructions for the removal of valuables in times of crisis	General (22)	Economic damage is caused to the organization due to the loss of valuable supplies during a crisis.	3	E	Moderate	Developing written instructions for the removal of valuables in times of crisis
Failure to develop instructions for protection and security of property and equipment after an emergency, lack of physical protection personnel	General (23)	Economic damage is caused to the organization due to the loss of valuable supplies during a crisis.	3	E		Developing written instructions on the protection and security of property and equipment after an emergency, increasing the number of individuals in the physical protection department
Are disinfectants and herbicides stored away from the ventilation system?	No ventilation system in the storage room for disinfectants and herbicides	Poisoning and suffocation	2	D	Moderate	Installing a ventilation system in the storage room for disinfectants and herbicides
Are diesel and propane stored away from buildings?	Poor storage of butane and propane (proximity to turbine hall)	Damage to core equipment such as generators in the event of damage to or explosion of gas tanks	1	E	Moderate	Building fire/explosion resistant walls

According to a similar process, the winter storm and extreme cold checklist have 1 serious risk, 1 medium level risk, and 1 low-level risk. Extreme heat checklist has 2 low-level risks. The chemical storage checklist has 2 medium-level risks. The earthquake checklist has 3 medium-level risks and 1 low-level risk. Fire and explosion checklists have 2 serious risks, flood checklists have 1 medium-level risk and 3 low-level risks, and the lightning checklist has 1 low-level risk.

To obtain a percentage risk for each checklist, high risks, serious risks, medium risks, low risks, and removed/non-existent risks were given scores of 5, 4, 3, 2, and 1, respectively, and their sum is placed in column (a) of Table 8. A maximum score of 5 is assigned to each risk and their sum is

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entered in column (b) of this table. The estimated percentage of risk for each emergency is given in Table 8. Percentage of risk for general emergencies (58.18), winter storms and extreme cold (80), storms (50), extreme heat (40), chemical stockpile hazards (60), earthquakes (55), fires and explosion (80), flood (45) and lightning (40) respectively. Based on these risk values, the emergency situations with the highest priority are in the order of fire/explosion, winter storm/extreme cold, chemical stockpile hazards, general emergencies, earthquakes, storms, flooding, extreme heat, and lightning.

Prioritization of corrective actions

As mentioned, the highest level of emergency preparedness (92%) was related to the lightning checklist and the lowest (63.33%) was related to flooding. Also, the highest risk level (80%) was found to be related to fire/explosion as well as winter storm/extreme cold and the lowest risk level (40%) was related to extreme heat and lightning. To determine the priority of corrective actions, the percentage preparedness and the percentage risk related to each emergency situation were plotted as shown below. In figure 2, the trend of preparedness for emergency situations from flooding to lightning does not match the trend of risk level for those emergencies. While, as mentioned, the lowest level of preparedness is against flooding. Since the highest risk level is not related to floods, the top prioritized corrective actions are for fire/explosion and winter storm/extreme cold, which have an 80% risk level, even though the highest level of preparedness is already in these categories (87% and 80%, respectively). The corrective actions with the

next highest priority are for chemical stockpile hazards, general emergencies, earthquakes, storms, flooding, extreme heat, and lightning, in that order.

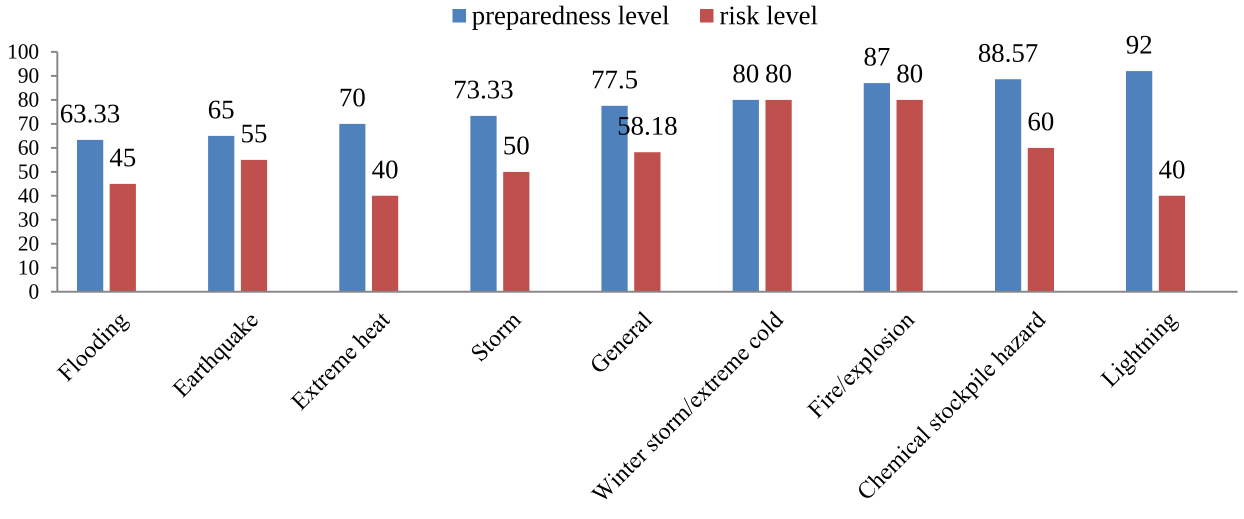

Figure 2: Comparison of percentage preparedness and percentage risk for each emergency

Discussion

Today, one of the most important and threatening challenges of any organization is emergencies and their possible consequences. Considering this issue, it is necessary to prepare and implement management programs to control and manage such conditions [20]. The emergency preparedness of an organization depends on a variety of factors including facilities and infrastructure, human resources, equipment, knowledge, training, and access to external resources [21]. The aim of this study is to identify and evaluate emergency situations in the southern power plant using the method of the Federal Crisis Management Organization. As no global research has been conducted in the power plant industry so far, FEMA guidelines have been translated and localized for the first time and a checklist has been extracted from them. As no global research has been conducted in the power plant industry so far, FEMA guidelines have been translated and localized for the first time and a checklist has been extracted from them. It is worth noting that the process and method of risk assessment in the power plant industry is not in accordance with a specific standard, and it is not necessarily to be in accordance with a specific standard. Also, with the researches done so far, no valid researches related to natural and artificial hazards related to power plant industries have been found and most researches in this field have been done in hospitals, schools, hotels, libraries, and at the level of households in the society.

The checklists and guides available on the FEMA website were collected and the required checklists were extracted for issues related to natural and unnatural (technical) emergencies in the power plant, which were identified by technical experts. Then, to check the validity of the checklists, the opinions of technical experts were used and the checklists were examined through the face and content methods. In order to evaluate the reliability of the research subjects, a test-retest test was used, and to measure the reliability of checklists, Cronbach's alpha coefficient was used with an emphasis on internal correlation, and the obtained alpha coefficient was equal to 0.76. Next, due to the nature of the checklists and the specialization of some of its questions, a team of 20 experts with relevant qualifications (industrial safety, firefighting, health, environment, crisis management) was formed to complete the checklists. After completing the checklists, the analysis was performed using SPSS 22 software. Next, the identified weaknesses were extracted from each of the checklists, and the possible risks arising from the existence of these weaknesses were also identified, then according to the standard [MIL-STD-882E], the risk level of each risk was calculated to prioritize and present the proposed solutions for the risks. In order to estimate the level of risk according to the standard [MIL-STD-882E], the severity and probability for each risk were determined and then the final risk level for each risk was determined. According to the results, as shown, the highest level of preparedness with 92% is related to the lightning checklist and the lowest level of preparedness with 63.33% is related to floods. As mentioned above, the highest level of preparedness (92%) was against lightning and the lowest (63.33%) was against flooding. Overall, while the plant was found to have varying levels of preparedness for different emergencies, it generally had above-average preparedness for all emergencies, which can be considered acceptable. However, some actions must be taken in every area to improve the plant's preparedness for situations such as extreme heat. This study found that while the lowest level of preparedness is for flooding. Since the highest estimated risk level is not related to this situation, corrective actions must be directed at improving preparedness for fire/explosion and winter storm/extreme cold, which have a higher risk level (80%), even though the highest level of preparedness is already in these categories (87% and 80%, respectively). Weaknesses associated with each hazard and related recommendations in each emergency are listed in table 8 in order of priority.

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Table 8: Prioritizing the Adoption of Lightning Control Measures Checklist

Weakness	Danger	Risk	Suggestion
Lightning			
Not having sterile sheets in the first aid kit	Lack of proper care for victims with burns	Low	Prepare sterile sheets
Chemical storage			
No ventilation system in the storage room for disinfectants and herbicides	Poisoning and suffocation	Moderate	Installing a ventilation system in the storage room for disinfectants and herbicides
Lack of proper distance between butane and propane gas due to proximity to a turbine hall	Damage to core equipment such as generators in the event of damage to or explosion of gas tanks	Moderate	Building fire/explosion resistant walls
Fire and explosion			
Lack of thickness measurement of pipelines	Gas or diesel leaks and the possibility of fire and explosion	Serious	Thickness measurement of pipelines should be done annually
Not using anti-spark tools	Possibility of explosion due to spark generation	Serious	Using anti-spark tools
Winter storms and extreme cold			
Impossibility to continue operating in conditions such as freezing turbine inlet or hardening of diesel and the impossibility of heating it	Economic damage to the organization due to inability to continue operating	Serious	Necessary measures for freezing and other emergencies that make it impossible for the organization to continue operating
General			
Lack of display of danger and accident hotspots in the maps	Life and financial losses due to non-identification of danger centers	Moderate	Reviewing the maps and identifying the centers of the accident such as fire, explosion, flood, and…
Clock system inefficiency in the event of a power breakdown	Failure to conduct a proper census during accidents and as a result the possibility of not searching for injured people and timely relief	Moderate	Determining a suitable method for a census during accidents
Limited security personnel and the impossibility of using other groups	Occurrence of further injuries and damages due to lack of timely assistance and impossibility of providing protection and security in emergencies	Moderate	Holding emergency assistance training classes for volunteer personnel from all industrial units, an increasing number of people
Lack of radio	Lack of timely information	Low	Procurement of radio and other necessary equipment

Weakness	Danger	Risk	Suggestion
Need to perform maneuvers to familiarize and inform the staff	Inability to apply the knowledge learned and react appropriately to events	Serious	Performing maneuvers to familiarize and inform all personnel
Need to conduct more training on emergencies such as earthquakes	Personnel injuries due to lack of familiarity with the necessary measures in the event of various accidents	Moderate	Training personnel to be prepared and familiar with the necessary measures in all emergencies
Impossibility to continue the operation of the power plant in case of serious damage such as the fall of power towers or gas line or damage to the main equipment of the units	Economic losses for the organization	Moderate	Anticipating alternatives for emergencies
Relative observance of the grooming system in the workplace by personnel	Existence of obstacles in access routes, the impossibility of timely access to emergency equipment such as fireboxes and capsules	Moderate	Requiring all personnel to use and fully implement the grooming system in the workplace
Non-segregation of any emergency in the instructions	Low	Lack of familiarity of personnel to take the necessary measures to prepare for various emergencies causes a lot of human and financial losses.	Emergency preparedness instructions should be prepared and provided to staff in a variety of emergencies.
Failure to develop instructions for the removal of valuables at times of crisis	Moderate	Economic damage is caused to the organization due to the loss of valuable supplies during a crisis	Developing written instructions for the removal of valuables at times of crisis
Failure to develop instructions for protection and security of property and equipment after an emergency, lack of physical protection personnel	Moderate	Economic damage is caused to the organization due to the loss of valuable supplies during a crisis	Developing written instructions on the protection and security of property and equipment after an emergency, increase the number of people in the physical protection department
Storm			
growing trees in the area of some facilities and equipment such as diesel tanks	Moderate	Trees approaching in the private aerial areas can lead to electric shocks or fires. Spread of fire to installations and equipment, trees, and…	Proper and timely pruning of all power plant trees
Installing windshield on	Low	The sudden opening	Providing wind shutters on

Weakness	Danger	Risk	Suggestion
top of doors and windows		of the door and collision with people	windows and doors
Extreme heat			
Not installing reflectors on windows	Low	Outside heat entering inside the building	Installing a suitable reflector on the glass
Not install sunshades on doors and windows	Low	Outside heat entering inside the building	Installing sun shades on doors and windows
Earthquakes			
Possibility of serious damage to cables and pipes in case of landslide	Moderate	Damage to equipment	Periodic inspections of cables, connections, and leaks of all energy pipes (gas and diesel) at shorter intervals
Stopping power plant units due to severe vibration because of increase in vibration	Moderate	Damage to equipment	Enable shut down for energy pipes
Failure to compile instructions for arranging equipment and devices properly	Moderate	Equipment collapse and damage to important and sensitive plant equipment	Developing appropriate instructions
Not sticking cellophane on the glass	Low	Breaking of glass, and pieces of glass injuring people	Sticking cellophane on the glass
Flood			
Severe flooding can be effective	Moderate	Damage to equipment, financial losses	Predicting the necessary possibility to prevent water from entering the buildings and equipment, providing the necessary facilities for draining water
Failure to install a one-way valve in the sewer	Low	Flood water entering the facilities and the risk of electric shock and damage to equipment and property	Installing a one-way valve in the path of the sewage
Not having a specific route (because there is no specific entrance to the power plant)	Low	Impossibility to control flood entry routes	Path control by the service unit periodically and during floods
Lack of control of sewerage networks	Low	Rising of sewage wells due to floods	Developing specific programs to control sewage networks (septic tanks, lavatory wells, etc.) for proper operation after floods

Various researches have evaluated the level of preparedness of work environments in case of emergencies. The results of this study are in line with previous researches, such as Bakhshi et al., which showed the hospital score in the areas of an emergency control system, communications and cooperation, critical emergency programs, emergency facilities, and emergency medical staff. The level of awareness of employees about crisis management and their readiness was assessed at a relatively good level [22]. In another study, the hospital's preparedness for diseases caused by extreme heat waves was evaluated. The results showed the importance of this issue and the good preparedness of the emergency departments in this field [23]. In Lebanon examined the preparedness of

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hospitals for natural disasters and emergencies. The results showed that all hospitals were ready, but only 83% of their programs included the recovery phase [24]. In another study, the preparedness of nurses working in rural hospitals in Wales was assessed against accidents, and their individual and organizational challenges were extracted [25]. A study of Pakistani schools assessed school preparedness for natural disasters, and the results showed that schools that implemented risk management initiatives responded more actively to disasters [26]. Khorsand Choobdar and Rahdar evaluated the preparedness of hospitals in Sistan and Baluchestan province in the corona crisis [27]. In a review study conducted by Sohrabizadeh et al. the degree of preparedness of health systems in different countries against weather events, earthquakes, and COVID-19 was studied and compared, and measures to increase preparedness were proposed [28]. Examined the preparedness of Iranian public libraries against dust in three stages: pre-crisis, during the crisis, and after the crisis. The results showed that the dust crisis in public libraries has not been considered so far, while this phenomenon can have a negative impact on the level of efficiency and performance of public libraries [29]. In a study by Mohammadi the assessment showed that these hospitals had an acceptable level of operational preparedness[5]. The results of this study are in agreement with the findings of a study by Ezzati, which reported an acceptable level of crisis and disaster preparedness in these hospitals [30]. The results of this research are also consistent with the findings of a study by Mohammadi which showed an acceptable level of crisis and disaster preparedness in the trauma and accidents departments of Kermanshah University of Medical Sciences [31]. Jadidi showed that the readiness of hospitals in Markazi province in the face of accidents and disasters is moderate [32]. Since accidents and disasters are always possible, the authorities should make more efforts to increase the preparedness of medical centers. Emergency preparedness and response is one of the most important components of crisis management and safety systems and standards. The reason for including the preparedness-related requirements in the mentioned standards is the importance of this issue for mitigating the consequences of incidents because all organizations are inevitably susceptible to hidden errors within their systems as well as situations caused by external factors Sometimes, these errors and situations turn into a crisis for the organization, causing major damage to its systems and functions. By being sufficiently prepared for emergencies, the impact of such factors can be significantly controlled immediately after they start to affect the organization.

Conclusion

Emergency response preparedness assessment has been performed mostly in hospitals, schools, and libraries. In none of the previous studies, the issue of emergency response assessment in industries, especially power plant industries, has been addressed and the FEMA method has not been used to assess preparedness. On the other hand, studies conducted in the field of emergency preparedness assessment have evaluated only one of the possible emergencies. The present study is for managing emergencies in the power plant industry and can be useful for all gas power plants with 94.2 v turbines and is effective in increasing the level of preparedness and reducing risks against emergencies. The use of the FEMA technique to assess emergency preparedness has been done for the first time in the country and also for the first time in a power plant, by using this technique, the weaknesses in emergency preparedness were identified. Checklists and guides on the FEMA site were collected and extracted for topics related to natural and unnatural (technical) emergencies at the plant. After confirming the validity and reliability of the checklists, 25 experts completed them. Next, the identified weaknesses were extracted from each of the checklists, and the possible risks arising from the existence of these weaknesses were also identified. Then, according to the standard [MIL-STD-882E], the risk level of each risk was calculated in order to prioritize and provide proposed solutions for the risks. The results showed that the highest level of preparedness, 92%, was for lightning and the lowest level of preparedness, 63.33%, was related to flooding. Therefore, adopting more control measures and measures to increase the level of flood preparedness is a priority over other emergencies. In general, the average level of preparedness for all emergencies was above average and is considered acceptable. Finally, the strengths and weaknesses of the power plant in the face of any emergencies as well as the risks associated with the weaknesses were identified. In the end, a list of corrective measures to reduce risk and increase emergency preparedness was provided to the organization in a prioritized manner.

According to the results obtained from this study, it is suggested that the Disaster Management Headquarters in the industry make the necessary predictions to conduct research in the form of a six-stage cycle of crisis management Frederick Kafi. Other practical suggestions include: holding safety training courses for industry employees, setting up tests or post-training courses, forming rapid response teams to deal with unexpected events, increasing credits in the field of crisis management, and more attention of different units to the discussion of disaster preparedness and the development of special action plans to deal with disasters can pave the way for the issue of disaster management.

Multi-criteria decision-making methods can also be used to prioritize remedial strategies and measures. It is suggested that in future research, all the natural and technical emergencies be identified and prioritized applying newer techniques such as Bow Tie Analysis. Each emergency situation should be identified along with controls and obstacles and emergency response plans should be developed for each of the emergency scenarios. The present study has some limitations, including the fact that the results of this study cannot be generalized to other times or places. Other limitations included the use of a questionnaire in the quantitative part of the study, which has its own inherent limitations, and also the lack of access to the information of other units due to security issues. In the research process, ultimately, disturbing and interfering variables may affect the research results that are uncontrolled.

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Conflict of interest

We have no competing interests.

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