International Academic Journal of Science and Engineering

International Academic Journal of Science and Engineering
Vol. 4, No. 1, 2017, pp.142-152
ISSN 2279-0039

International Academic Journal of Science and Engineering

www.iaiest.com

Zoning Seismic Risk Areas of the Shiraz Gas Company Regions with Passive Defense Approach Using GIS and AHP Model

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Abstract

One of the critical passive defense measures associated with gas installations, is examining the susceptibility of these facilities and identifying their vulnerabilities in critical situations, therefore we may minimize the damage from potential damages. This study intended to investigate the Zoning seismic risk areas of the city gas regions with passive defense approach using GIS and AHP model. The aims of the present study were: 1- Studying the principles of Passive defense (Location, camouflage, dispersion, hardening, strength, etc.) of gas installations 2- Zoning limits of vulnerability identification and gas facilities from the perspective of passive defense, and provide solutions to reduce the vulnerability of areas of gas facilities and gas installations of Shiraz when faced with the threat of earthquakes. For this purpose, to achieve the first objective, all sensitive installations important in terms of defense principles were studied. And in order to achieve second objective, to prepare the hazard zoning map7 Effective measures included: The distance from the epicenter of the earthquake, distance from the fault, geology, height, depth to groundwater, slope and aspect components were mapped in GIS, weighted and overlaid. Finally, the area was zoned based on the priority level of risk to 5 districts. The results showed that: a complete revision in gas installations in terms of the principles of passive defense, especially in terms of strengthening the fortifications to be should done. In terms of risk based on the AHP model, Shiraz surface level is of 7, 17, 27, 28 and 22 percent in areas of very low risk, low risk, medium risk, and high risk and too much risk. Based on the AHP model, were gas zones 1, 2, 3 and 4 respectively. The field observations and documentation of assessment models in the gas company indicated that the AHP model has good performance regarding earthquake hazard zoning in the studied area.

Keywords: Gas supply, passive defense, GIS, earthquake, AHP

Introduction

In the present period, passive defense is going to reduce modern threats results from rapid development and revolution in information technology, such as geographical information systems, remote evaluation and creating expand scope of threat that cause to create diversity and expansion in different executive and defensive area. Proceedings which are done for creating stability and deterrence include: 1- management proceedings 2-technological proceedings 3- engineering and strength proceedings 4- software proceedings.

Among these proceedings, technological proceedings are considered like geographical information systems more than ever. Geographical information systems have important and sensitive defensive abilities and informational which todays can be considered in programming and deciding on passive defense.

Todays, gas pipelines play a significant role as an important vital artery in continuing human life and supplying comfort and peace. But according to expansion and area of gas pipelines throughout the country, this vital artery faced with many risks, problems and threats, especially in an earthquake which cause to breakdown gas pipelines, gas branches pipeline and falling station walls of reducing pressure and as a result cause explosion and fire that has many consequences. Of the main gas delivering installation stations, same cases can be mentioned in order of importance, such as gas refineries and main transformation gas pipelines, city gate stations of reducing pressure (C.G.S) and town board stations of reducing pressure accompanied with distribution networks, in-house consumption networks and gas pipelines . One of the important and fundamental proceedings of passive defense regarding gas delivery installations is to evaluate vulnerable area and to identify vulnerability of these installations and to recognize vulnerability points to minimize damages of probable attacks through it.

Therefore, at the first step, gas delivery installations are categorized based on important, sensitive and vital categorization and then, in the following, they are categorized based on informational risks, earthquake, which is a source of threat in the view of passive defense according to risk rate, into 5 groups that includes: 1- very low risk 2- low risk 3- medium risk 4- high risk and 5- very high risk. Then by using AHP model and ArcGIS software, zoning map of risky regions of gas delivery area will provide. At the end, according to passive defense and risk rate each area, defense measures of every area will analysis in gas delivery.

Theoretical basics

Passive defense: is a set of proceedings which didn't need to apply armaments and by its execution we can prevent financial damages in equipment and human installation or reduce damages and mortality as minimum as possible [2]. Or, on the other words, passive defense is financial damages reduction and personal injury in un-armed persons in war or natural disaster such as flood, earthquake, storm, volcano, fire and drought [3]. One of the most important goals of this kind of defense is immunization and to reduce vulnerability of needed infrastructure in order to create conditions for safety.

Threat: phenomenon that put in risk the interests and fundamental resource (such as material and spiritual, independency and territorial integrity, economical resource, cultural and national values, political goals and interests, armed abilities and etc.), in a way that fear of changes will be found, is called threat.

Camouflage: means to monochrome and shape up all installations and equipment by surroundings.

Strengthening: performing special engineering designs which cause to increase persistence of installations in distant places and also construct units in every industrial complex with suitable distance from each other [5].

Vulnerability: amount of harm and damages of factors and potential phenomenon or actually damageable towards human resources, equipment and installation with intensity of zero to 100 percent is called vulnerability [4].

Rating: is called for determining importance level of infrastructures and its ranking which is based on national regional and local effect level, and other measures and index in three vital, sensitive and important levels [6].

Vital centers: centers that if destruct totally or partially cause to create crisis, damage and significant harms in political, conduct, control and command, producing and economical and support, relational and road and social, defensive systems with effecting level throughout civil and city complex [5].

Sensitive centers: centers that if destruct totally or partially cause to create crisis, damage and significant harms in political, conduct, control and command, producing and economical and support, relational and road and social, defensive systems with effecting level throughout civil and city complex [5].

Important centers: centers that if destruct totally or partially causes to create limited damage and harms in political, social, defensive systems with effecting levels of area and local [5].
Vital arteries: includes set of networked infrastructure constructions which in general are gas, water, electricity, telecommunications and wastewater networks. Destructions or failure of each of these mentioned arteries may have secondary damage such as gas or oil pipelines which if be threatened, in addition to service interruption when needed, cause to create expand fires, as sometimes fire damages are many times more than primary damages.
Geographical information systems: geographical information systems are composed of a set of hardware and software which are used for entry, process, and storage and applying geographical information. In fact GIS is a kind of technology that its usage, management and organizing local and descriptive data on the earth become possible by aim of optimal decision making. This technology has been developed during two past decades rapidly, as it has been accepted as a necessary tool for effecting use of local information [8].
Passive defense principals:
General passive defense principals are: [9]

1) Localization 2) dispersion and division 3) strengths 4) camouflage 5) secrecy 6) coverage 7) deception 8) announcing

Kinds of common methods in passive defense are: [9]

1) Camouflage 2) secrecy 3) coverage 4) deception 5) division and dispersion 6) strengthen and retrofit 7) announcing.

Passive defensive and crisis management were evaluated in two separate topics, one in military viewpoint and the other in natural disaster viewpoint, but at present, these two topics have close interaction and relation and become a common science. By this comprehensive viewpoint, it can be said that passive defensive, is a comprehensive crisis management in defense area.
Study background:
Golmehr (1388) in on article termed "evaluation of civil installation vulnerability by passive defense approach – case sample presentation- evaluates Birjand as a boundary by presenting a method which analyzes the city and its effective elements on passive defense topic by using AHP method and GIS software and interpolated compression and finding presents vulnerability zoning map of Birjand city and suggests about probable damage reduction of military attacks. [10]
Gohari et al. (1392) in an article called "identifying vulnerable zones of Mertary Bahonar town of Mashhad, identifies vulnerable zones of passive defense in a multi-criteria analysis by using GIS and space syntax software and quality analytic approaches of AHP and Delphi and weighted overly analyzer and finally suggests about vulnerability domain reduction of passive defense in Mertary Bahonar town of Masshad. [11]
Taghi Nejad et al. (1392) in an article termed "defense vulnerability of civil structure by using hierarchical analysis of AHP and GIS of Gorgon case study", has evaluated city vulnerability in wars and has codified suitable solutions for reducing vulnerability and damages and has divided Gorgan into 11 zones as a case study and has determined different zone vulnerability of city by using hierarchical analysis and geographical information system and finding has determined zones which have more vulnerability because of high structures and population density during war and military attack.
Investigation method:
This investigation is a kind of applicable-problem solving. Required data collection instruments in this investigation had been like observations, questionnaires and interview with related experts and documental methods (referring to written resources, such as books, articles and reports, etc.). In this study, two hierarchical analytic and entropy Shanon model have been used.

Materials which are used in this study for zoning map of risk against earthquake risk, as a threatening factor in passive defense which include distance measures from fault lines, distance from earthquake center, geology, slope, underground water depth, slope orientation and height. These criteria are derived from following data:

1. Topographical 1:25000 maps of geology organization in order to provide height model of digital region and providing slope map, slope orientation and height from height digital model. 201:100000 maps of geological organization for providing geological formations and region faults.

3- Piezometric data of Shiraz plain for providing underground water depth. 4. Statistics of few last year earthquake of Shiraz – earthquakes higher than 3 Richter become a unite torque magnitude (MW) for better analysis. 5. 1:20000 city maps. 6. Data and information of gas delivery installation (reducing pressure stations, networks, pipelines, branches and gas users). Used models for zoning earthquake risk:

In recent decades, many investigators pay attention to multi-criteria models for deciding in real conditions. In this study, hierarchical analytic model and entropy Shanon model are used.

Studied limit:

Shiraz by geological coordination of east longitude of 52/33 and north traversal 29/36 in more than 1500 meters height from see level and by area of 1098818 square kilometers, is located on Fars province center, approximately. In the north of Shiraz, there are Marvdasht and Sepidan and Firuz-Abad and Jahrom are located in its south. Neyriz, Estahban Fars are located in East of this city. Shiraz city includes 6 divisions, 5 town 21 villages and its population is more than 1263244. Divisions of Shiraz city are: central division, Zarghan, Korbal, Kavar and Arjan division.

Shiraz is the first city of Iran that is used of natural gas energy in industrial, commercial and house divisions and benefits from its manifold advantages such as good fire, cheapness, clearance and easy access. Shiraz population was about 599500 persons according to 1345 statistics. Shiraz gas delivery includes gas delivery region (figure 1).

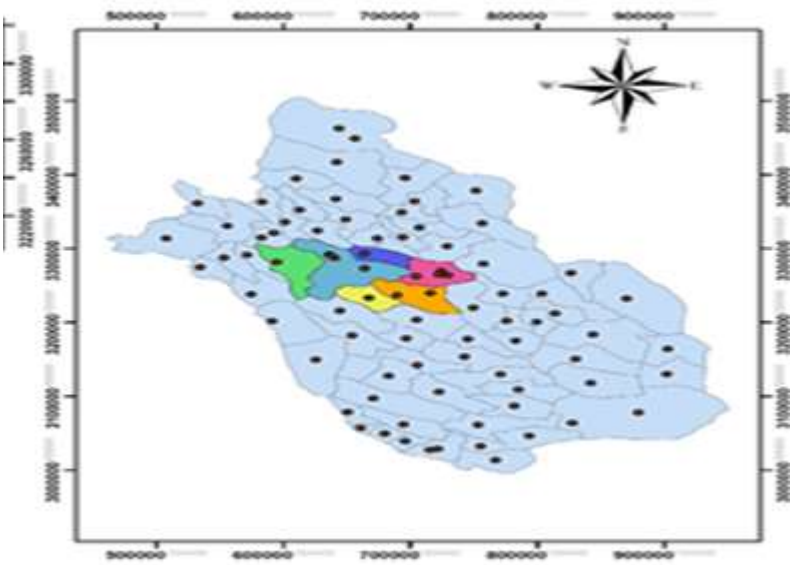


Figure 1. Centre situations (A) Fars province gas delivery- (B) Shiraz delivery gas – (C) Shiraz gas delivery (authors)

Investigation findings and analysis:

Used output maps in earthquake zoning (figures 2-8))

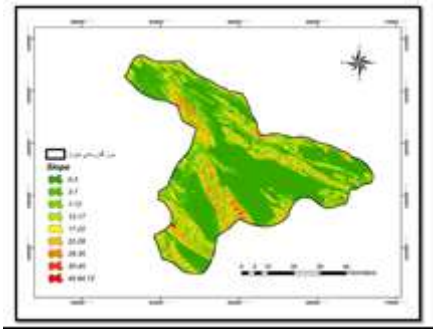


Figure 2. slope classification map (authors)

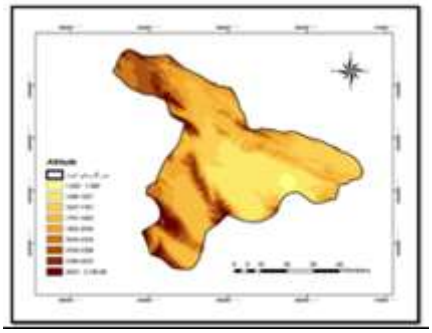


Figure 3. region height classification map (authors)

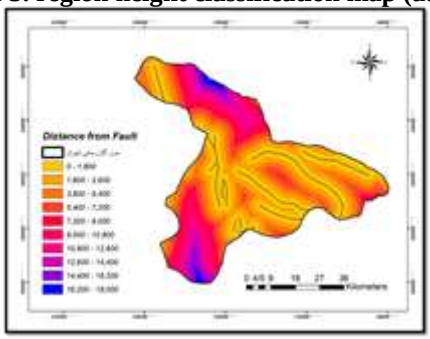


Figure 4. classification map of distance from fault (authors)

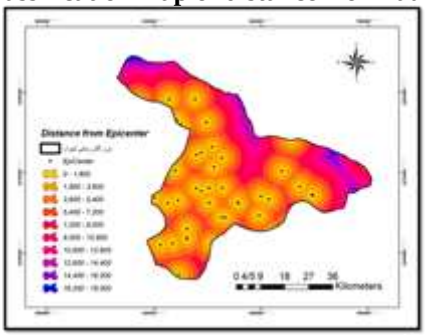


Figure 5. classification map of distance from earthquake center (authors)

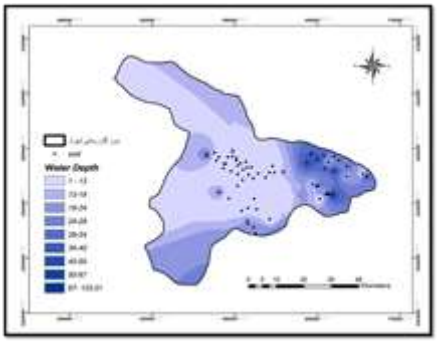


Figure 6. classification map of underground water depth (authors)

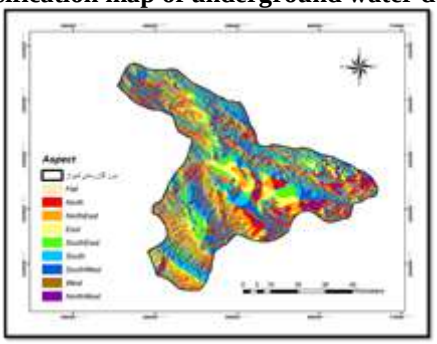


Figure 7. classification map of slope orientation (authors)

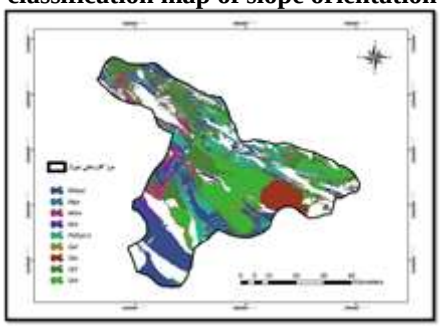


Figure 8. classification map of geology (authors)

Zoning results in AHP method:

One of the best methods of determining criteria values is hierarchical analysis model (AHP). Binary comparison method by Satty in 1980s is represented in the field of hierarchical process (AHP), which in this method, comparisons between criteria is used as binary and proportional weights are created as outputs.

AHP method which experts ideas were intervened in it, we do layers weighting which results have been shown in importance priority.

(("water_re"*0.028)+("slope_re"*0.051)+("litho_raster2"*0.179)+("fault_dis_re"*0.287)+("epicenter_re"*0.390)+("aspect_re"*0.032)+("altitude_re"*0.035))/1

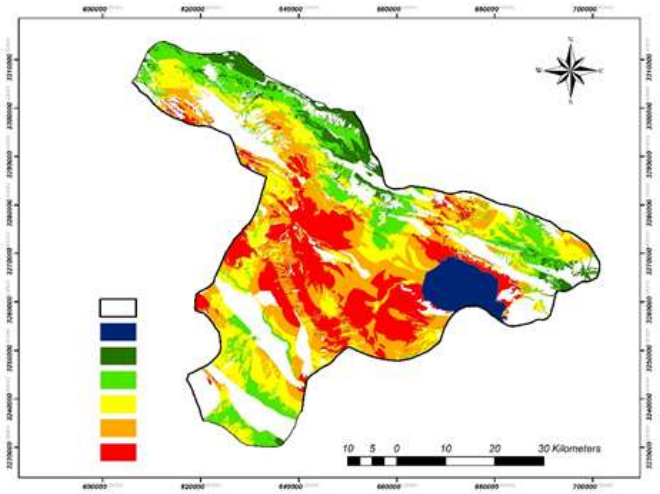


Figure 9. classification of dangerous area

.

Faseleh az kanon zelzelh	.390	
Faseleh az Gosal	.285	
Sazand Zaminshenasi	.179	
Slope	.051	
Altitude	.035	
Aspect	.032	
Omgh AB zirzamini	.028	
Inconsistency = 0.08		
with 0 missing judgments.		

Table 1. comparison of criteria in expert choice (authors)

Threats and existed problems in gas delivery installations can include happened problems on gas interruption effect, or gas explosion results from gas leakage because of human-made or natural factors on threats, which each one accompanied with some results. In this investigation, fault as one threat and earthquake as one of the natural risks are evaluated in figure (10), which faults and gas delivery installation and gas users are shown in GIS software environment. As it can be seen in figures, most of gas users (statistical society of this study) are on risky regions. Therefore, passive defense considerations must be evaluated in view of strengthening residential house, economic and etc. also entrance way in order to help in these region.

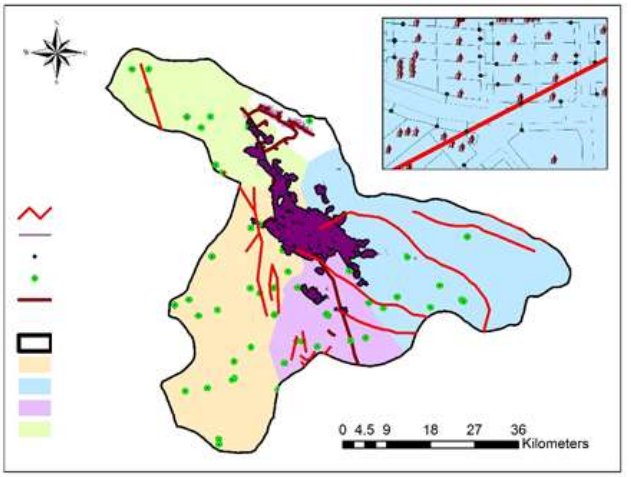


Figure 10. floor area, earthquake risk and gas delivery of Shiraz by AHP method (authors)

Relief unit (crisis staff center) and 8 regions of relief unit as one of the main units during crisis management was evaluated regarding with passive defense and the relations of these centers with risk zoning in GIS were evaluated and finally zoning maps of octonary centers of relief posts were prepared.

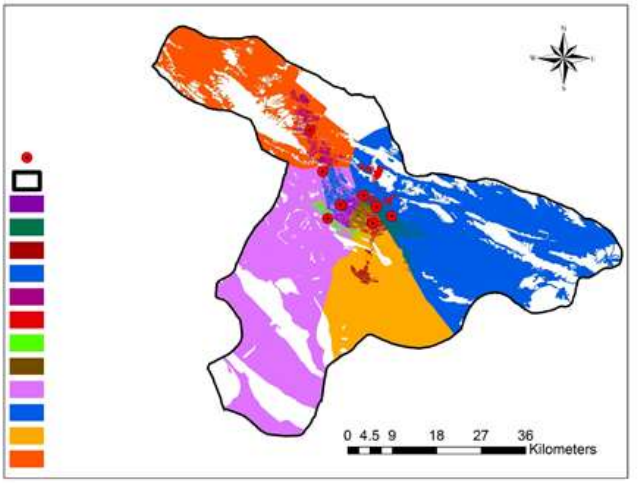


Figure 11. Final maps of risks gas delivery area of Shiraz and relief posts places of AHP model (authors)

Analysis principals of passive defense considerations in gas delivery installations:

Table 2. passive defense principals in gas delivery installations

	branches	60 pounds network	250 pounds network	TBS stations	CGS stations
Localization			Non-situating close or in the vicinity of streams and	A)non-situating in crowded in city centers B)non-situating in	A) non-situating stations close to high ways, roads, rivers. B)access ways to

			faults	the vicinity of high risky city centers	stations are not easy accessible C)they constructed in distant access places
Camouflage				Camouflage stations by using colors (such as earth color)	Camouflage stations by using colors (such as earth color)
Strengthening and retrofitting	Retrofitting pipelines and old branches, in old region and close to faults	Acceleration in od networks	Acceleration in od networks	A)retrofitting station walls B)retrofitting station installations	A)retrofitting station walls B)retrofitting station installations
Dispersion					Evaluating and observing future installation than other existed installations
secrecy				Sharing installation usually and non-important in city	Using canopy in different shapes and colors

The most principals of passive defense which are evaluated in gas installations include:
1) Localization 2) camouflage 3) strengths and retrofitting 4) dispersion 5) secrecy which mentioned principals were evaluated in table 2.

Conclusions:

The most important goal of passive defense is to prevent of creating crisis and stay away from creating crisis conditions and in the event of crisis happening is to create conditions for rapid control of situations and restoration conditions in to before crisis conditions. So, it will recognize that by observing passive defense, vulnerability and crisis happening will reduce severely.

At the present, the most general goal of passive defense is to immunize and reduce conditions for people safety gradually. One of the most important and basic proceedings of passive defense is to gas delivery installation, evaluate vulnerability in these installations and identify vulnerability points in order to reduce damages results from probable attacks and damages through it. Gas installation classification regarding to classify vital, sensitive and important centers and other installations in the view of creating disorders are in table (3), shortly.

Table 3. classification of gas installations (authors)

Installation types	Classification
Gas refinery	Vital centers
CGS station	Sensitive centers
TBS station	Important centers
CNG station	Leakage or disorders in stations risks of firing and exploding, etc.
Pipelines	Cause to gas delivery disorder for related users or disorder in gas

	delivery of multiple users
Branches	Cause to gas delivery disorder for related users or disorder in gas delivery of multiple users.

In AHP model, after doing weighting for selected layers by using experts idea, results showed that effective factors include distance from earthquake center, distance from fault, geological formation, slope, height, slope orientation, underground water depth are in importance priority.

-Based on AHP model, Shiraz is situated in area of 16996 hectares (7 percent) in very low risk region, 4476 hectares (17 percent) in low risk, 68829 hectares (27 percent) in medium risk region, 71622 hectares (28 percent) in high risk region and 55670 hectares (22 percent) in very high risk region through effectiveness, respectively.

-In AHP model, priority of risky region of gas delivery area include area 1 of gas delivery, area 3 of gas delivery, area 2 of gas delivery and in the least priority is area 4m regarding to the highest amount of risk, respectively.

Obtained results of this study are conformed to obtained results of Ebrahimi et al. (1394) regarding seismicity and obtained results of qualitative evaluation of seismicity vulnerability of TBS stations of Shiraz gas network by Rahnama (1395).

As a result, regions with high and very potential risk, generally are located on low height and low slope plains on Quaternary alluvial sediments and on underground water tables (by near earth surface depth), include Shiraz plain, Kavar and Siakh Darengun plain and regions with high and very high risk are seen in North West, west, south and west south of Shiraz.

According to obtained results of AHP model of this study, on one hand and risky region of south and west south of Shiraz, situation of TBS stations no. 22 to 27 in this region, all are confirmed correctness of obtained result of AHP. Therefore, studied region generally is of high risk region regarding seismicity and passive defense consideration in all gas delivering region should be considered. But in area 1 of Shiraz gas delivering considered more.

Suggestions:

1- Retrofitting and strengthening: identifying old and weary region and collecting installed branches in these regions specially area 1 of gas delivery.
2- Retrofitting and strengthening: acceleration in old network changes.
3- Retrofitting and strengthening was stations of CGS and TBS in order to prevent of falling on related installations and disorder in gas delivery in different region during crisis and threats and probable risks, because in most of time, strength of stations observed according to standards but because their surrounded walls have not necessary strength and persistent cause to fall on installations and disorder.

4- Camouflage: in order to camouflage sensitive centers such as CGS and important centers of TBS, suitable colors such as earth color can be used.

5- Secrecy: in order to secrecy of sensitive centers of CGS and important centers of TBS it is suggested to use canopy by shapes and colors proportional to environment.

6- As passive defense and crisis management have a close and non-separable relation with each other, it is suggested to consider and implement all considerations of passive defense about gas delivery installations such as reducing pressure stations, pipelines and branches and gas network with 60 and 250 pounds pressure. This problem cause to improve and accelerate function during crisis and after crisis.

7-Localization: in localizing reducing pressure stations regarding with passive defense, it is suggested to evaluate access way of installation in addition to conditions which considered during installation designs, and considered as such they are not easy accessible, and secondly its dispersion related to other reducing pressure stations observed and thirdly, they situated on distant places (secrecy).

8- It is suggested that relief center constructions (crisis staff center) and 8 relief post centers reevaluated regarding passive defense principals of strengthening and retrofitting and constructions that have not these required and necessary standards reevaluated. Also, the least required and necessary equipment in these constructions should supply in these constructions during crisis or threats and human-made or natural risks.

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