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Development of a Fire Safety Checklist for Dormitories

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ABSTRACT

Background: Despite advances in technology, people are still exposed to fire hazard. Students can be one of the most important exposed groups. Therefore, fire safety inspection should be established in dormitories. The aim of this study was to develop a fire safety checklist for fire safety inspection in dormitories.

Methods: This study was as a tool development followed by a cross-sectional study in dormitories of Zanzan University of Medical Sciences. The initial items of the checklist were extracted from formal standards and regulations. According to comments of the expert panel group (n = 5) and Law she method, the validation of the tool was confirmed. The reliability was accepted based on Cronbach's alpha coefficient. In field study we used the tool to inspect fire safety status of Zanzan University of Medical Sciences dormitories.

Results: The initial checklist contained 68 items. According to the comments of a group of expert panel, some items were added to the checklist and a couple of them were removed. Finally CVI & CVR for 62 items were, over 0.7 and 0.99 respectively. The Cronbach's alpha was equal to 0.74.

Conclusion: This study could develop a valid and reliable tool for inspection of dormitories fire safety.

1. Introduction

Fire is one of the important safety aspects in buildings and structures. The number and intensity of the fire, explosion, casualties and injuries are increasing continuously (1). Several facts about fire and related burden have been revealed by responsible organizations and agencies. The National Bureau of Statistics of America announced that almost one million fires occur in a variety of buildings and workshops every year, which cause about 8,000 casualties and more than 20 billion dollars of damage (2). According to The National Vital Statistics Report (USA-2010), 2782 people lost their lives because of encounter with fire smoke and flames (3 4). In Iran, in 2014 the

number of people who lost their lives due to burns from fire outbreaks, has been reported 1810 people (5). The risk of fire in buildings is different. According to fire statistics, about 6611 cases of occurred fires in Tehran (2002), belong to dormitory buildings. In comparison with the previous year, this ratio has increased (6).

Dormitories are one of the residential buildings housing young people (students). Safety against fire is of paramount importance in dormitories, since the students who shape the country's future, spend the best years of their lives in dormitories.

However, dormitory fire statistics is distressing. The Fire Department of USA reported that during 2009-2013, there were 3810 fires in dormitories, barracks and other similar places that brought \$14 million direct cost, 86% of whom occurred in cooking parts (7).

Presently, Iran has 58 universities of medical sciences that cover a total of 500 dormitory buildings with 40 percent of the students (about 70 thousand) living in dormitories (8). In Isfahan (2007) a fire occurred in one of the university dormitories due to a loose electrical connection and inappropriate wiring. Lack of fire alarm and automatic extinguishers, as well as locked emergency exits caused 78 people injured (9).

A fire occurred in dormitory of Karaj Agricultural College (2015); caused by electrical wire firing (10). Fire in Shahid Rajai University dormitory of Shahr Kord (2015) inflicted remarkable financial and economic losses (11).

Fire in the Science and Industry University dormitory is another case (2009) in which the fire started in the basement of dormitory (powerhouse) and spread a lot of smoke to the upper floors of buildings causing students to panic. (12).

In case the checklists are designed properly, they will be one of the valid assessments. A checklist will look favorable in terms of content; when enough objectivity, reliability and reproducibility exist especially in the subject (13).

In a study concerning how to design checklists Daniel, describes twelve checklists designing steps (13-16): consolidation task checklist; the initial design checklist items; classification and sorting items; definition and demystification groups; highlighting other groups; initial assessment; potentially revising the content; identification and map format checklist; re-evaluation; the final stage of finishing; dissemination and application; periodic review and modification of checklist. In order to design a checklist with desirable features, it is necessary to design and build it in three different phases to be considered (17). In the first phase, people in target groups will be interviewed for data collection. In the second phase, experts in

the relevant fields will be surveyed and finally in the third phase, tool internal stability (Cronbach's alpha) will be measured.

Fire statistics in developing countries indicate that more than 75 to 80 percent of fires are predictable and preventable (18-20). A significant factor in the prevention of fire outbreaks is maintenance and inspection. To access this point, we need the right tool. The most commonly- used tool for this purpose is the checklist (21). The checklist is a tool quickly trained and applied. The Checklist is a memory aid tool for gathering information and if designed correctly, can ensure integrated data gathering, and the survey of all pre-arranged cases. However, making a fire checklist requires expertise and safety insight, and inexperienced safety attendants may encounter difficulties and confusions in fulfilling the process (22).

Various studies have used different number of items to design checklists. But by now there has been no perfect tool for monitoring dormitory buildings in Iran, therefore, it is necessary to prepare a standard tool. The purpose of this study is to prepare a checklist (a valid and reliable tool for evaluating the fire safety of dormitory buildings).

2. Materials and Methods

Two methods were used in this study, the first step: designing the fire safety checklist for dormitory buildings, and the second step: a Cross-sectional study. To implement the first step, library research was conducted, which aims at getting the appropriate items. To create the items of the above- mentioned tool, the related regulations and guidelines were used. It should be noted that any fire safety regulations are limited by the fire outbreak, fire growth, and fire spread.

Also, the instructions prevent the buildings from collapsing due to fire, allow residents to be evacuated safely and give the accessibility to firemen to enter the building and extinguish the fire (23).

What is happening today in most countries, including Iran, is providing a framework for protective measures against fire based on the building regulations (24). For this reason, the main reference to acquire the items was the third and thirteenth Iranian Building National Regulations Topics (Protection of buildings against fire and the design and implementation of electrical installations) (25, 26). Then we accessed the other essential references; such as regulations of Labor Department and Standards of Education Deputy and Prevention of Fire Stations and Safety Services Department (Exclusively instructions of buildings fire protection) and also Publications of Strategic Planning and Control Deputy (27). On the other hand, dormitory accidents investigation showed that it is necessary to classify the checklist items into four categories including exits, fire detection and auto-extinguishing system, building's electrical systems, gas systems and powerhouse (9-12).

Ultimately, the items were improved from conceptual and structural aspects (based on opinions of dormitory wardens and students). In this study, after designing the checklist, to verify the validity and internal consistency (reliability), content validity method and Cronbach's Alpha coefficient were used.

There are several methods for determining the numerical content validity of the checklist. In the present study, owing to multidimensional nature of the study and including various structures in designed checklist to determine the content validity we used Law she proposed method which is designed for multifaceted studies (21). To this end, the checklists were given to expert panel (with minimum possible number ($n = 5$) to do the best consolidation). This panel included two professors of Occupational Health Engineering, two attendants from the fire department forces and an architect from the Engineering Organization.

Two indicators were considered to compute the content validity. The aim of CVR calculation ratio was to determine the necessity and importance of the checklist items from the experts standpoint. After the interpretation of the forms, CVR ratio

was calculated by the following formula for each item.

Equation 1:

$$CVR = \frac{n_g - \frac{N}{2}}{\frac{N}{2}}$$

- n_g : The number of experts who have responded to an essential option.
- N : The number of all experts.

Table 1 shows the commentary of accepted amounts of CVR corresponding to components of the panel. Thus, based on the number of people who participated in validation stage, there is a special CVR and the higher the number of panel members, the lower the accepted amounts of CVR will be (21).

Criteria for acceptance or rejection of items:

1. The item is accepted if the value of the CVR is equal to or more than 0.99. This number was obtained based on the number of five-member panel of Table 1.
2. The item is accepted if the value of the CVR is between 0 and 0.99 and the average number of judgments is equal to or more than 1.5.
3. The item is not accepted if the value of the CVR is less than 0 and the average number of judgments is less than 1.5.

The purpose of computing CVI index, is to determine the clarity, simplicity and relevance of the items to the study targets from expert's view and represents the items ratio which received a good rating from experts panel (28, 29). The CVI amount is already the average of remaining items of CVR in a valid model, test or tool. CVI represents comprehensive judgments related to validity or applicability of the model, test or the ultimate tool. The higher the content validity, the more the amount of CVI tends to 0.99. The opposite is also true.

Equation 2:

$$CVI = \frac{\sum CVR}{\text{Retained Numbers}}$$

Table 1: Variables on CVR.

| No. of | Min. | No. of | Min. | No. of | Min. | No. of | Min. |
|---------------|-------|---------------|-------|---------------|-------|---------------|-------|
| Panel Experts | Value | Panel Experts | Value | Panel Experts | Value | Panel Experts | Value |
| 5 | 0.99 | 9 | 0.78 | 13 | 0.54 | 25 | 0.37 |
| 6 | 0.99 | 10 | 0.62 | 14 | 0.51 | 30 | 0.33 |
| 7 | 0.99 | 11 | 0.59 | 15 | 0.49 | 35 | 0.31 |
| 8 | 0.85 | 12 | 0.56 | 20 | 0.42 | 40 | 0.29 |

- CVI: Content Validity Index
- CVR: Content Validity Ratio (Direct conversion of linear and members of the panel that selected "essential").
- Retained Numbers: the amount of remaining items

To use the designed checklists in current fields, determining the validity is not enough, and identifying the reliability is required as well. Thus, though the checklist was made using different texts and experts, we need to examine the empirical and real perspectives (30, 31). The reliability of measuring instruments is a degree of stability, consistency and predictability in whatever that is measured. At this stage, for determining the reliability of the checklist and monitoring the state of fire safety, it was used in all Zanjan University of Medical Science dormitories and, internal consistency (with Cronbach's alpha) was determined based on the results.

SPSS_16 statistical software was used for statistical analysis of the data.

3. Results and Discussion

Fire outbreaks statistical analysis in dormitories and similar places showed that the items of checklist need to be classified into four different parts:

- Exits: The checklist items in this part include the number and capacity of exit options, stairway and hallway lightings, emergency exit signs and guides and emergency exits. Assessment of references led to the first fire safety checklist with 19 items.

- Fire detection and auto-extinguishing system: this section contains items to check the status of fire extinguishers including the expiry date, availability and protection, and fire alarm systems. Assessment of references led to the first fire safety checklist with 9 items.

- Building electrical systems: items of this part include electrical installations, the equipment, and connections and sockets with 9 questions.

- Gas systems and powerhouse: items in this part includes generators safety and boilers, flanged connectors and valves, boilers distance standards, etc. Assessment of references led to the first fire safety checklist with 21 items.

Also, after validity, 6 items were removed. The amount of content validity index was calculated using equation 2, as follows:

$$CVI = \frac{\sum CVR}{\text{Retained Numbers}} = \frac{43.8}{62} = 0.706$$

According to CVI computation, proposed by Hogan (Hoghan-2001), we used the opinions of experts' panel (32) to changes the wording and structural reforms of items. Thus, a fire safety

checklist was designed for dormitories in which the amount of CVI (content validity index) is an acceptable value (0.706). Finally, the number of items with the changes reached 62. The checklist inserted in appendix section, was made by using different texts and improved based on experts panel opinions. However, it should be examined from the empirical and real perspectives (30, 31).

To fix this flaw, the reliability of instrument was computed and the amount of Cronbach's alpha coefficient obtained to be 0.74 which indicates the reliability of the above checklist.

The second part of the study was to evaluate the dormitories using a valid and reliable checklist.

This evaluation acquires the following information:

This evaluation gets the following information:

- In none of the dormitory buildings, the Emergency exit ways were specified with appropriate signs or marks.
- In none of the dormitory buildings, the manual fire alarm system was used and other fire equipment was not also used except fire extinguishers. Besides, computer sites and libraries of dormitories were not equipped with

fire extinguishers. Generally, dormitory buildings fire safety status in sections exits, fire detection and auto-extinguishing system, building electrical systems, gas systems and powerhouse were computed to be 54.6%, 44.4%, 56.2% and 73% respectively (based on the safety degree against fire). The total state of fire safety in dormitory buildings was evaluated 58.6 percent.

Implementation of this part helped with the better adjustment of the items to the study environment and approval of the checklist reliability and internal consistency. During the process of reliability of checklist, one item from safety list related to exit options, and one item from safety list related to powerhouse safety were removed and replaced by other suitable items.

4. Conclusion

As mentioned previously, there is no perfect checklist to monitor the dormitory buildings fire safety status. Generally, studies concerning fire safety status of buildings have developed checklists based on their own resources, thus, the designed lists may not be appropriate or applicable to all buildings especially dormitory buildings.

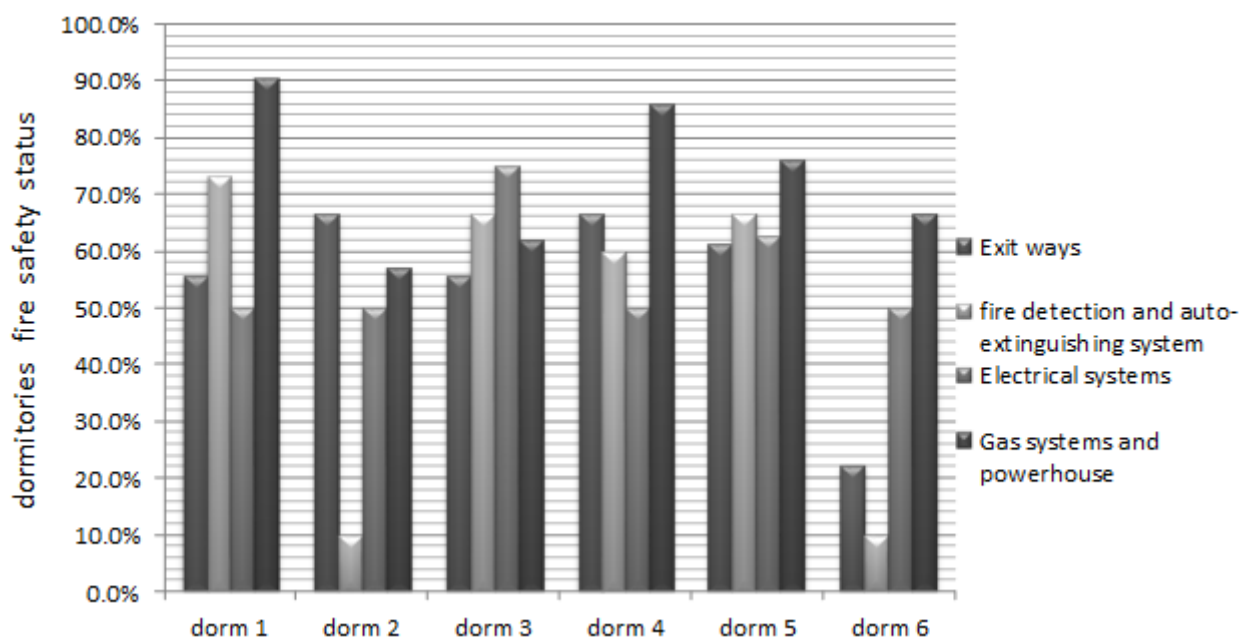


Fig.1: The results of reliability (based on different check list items and dormitories).

In a study on earthquake vulnerability reduction and fire hazard in student dormitories conducted by Bashiri et al. (2014) (33), considerable questionnaires and interviews were seen.

However, in safety part, the different sections of dormitories have been neglected. For example, because of students' frequent crowd in these places, they are at different risks and the outcome of events. If not protected. Also, the above-mentioned study analyzed only two of the possible fire risk factors (causes structural and non-structural building) in dormitory buildings. Safety factors such as the building electrical systems, fire automatic extinguisher system, emergency exit routes, and powerhouse system have not been studied and analyzed.

Yarahmadi et al.,(2010) , used a checklist based on risk assessment method to assess the fire safety situation (34). The study calculated the level of risk using one potential risk assessment method, and since the right tool was not used to assess the building fire safety, it did not lead to the construction of appropriate inspection tool for dormitory building fire safety.

Dormitory surveys determined some defects, e.g. electrical failures. This could be a cause of increased risk. For instance, in the USA 47,700 fires in residential buildings and about 16,400 fires in non-residential buildings fires were reported due to a failure in electrical system (2011), with losses of more than 1.4 billion dollars in residential buildings and 501 million dollars in non-residential buildings (35).

In the dormitories manual fire alarm system and other fire equipment was not used except fire extinguishers. According to the designed checklist, the computer site and libraries of dormitories must be equipped with fire extinguishers, but this was not observed. Fire accidents that indicate. That fire alarms can be a life- saving tool For example, in 2014 due to fire caused by an accident on the Tehran Jomhuri Street, a number of people lost their lives. Due to the lack of fire alarm systems, residents had not noticed the fire in early stages of development (36).

Contemplating the methodology of the study also concluded that researchers did not use the CVI and CVR computational criteria for validation of their checklist and have sufficient just to comment on experts opinions about their items in limitation of Likert scale; Which in this case because of lack of area specialists comment, the error probability is larger. While the initial checklist sources in their study was limited to two cases which one of the sources is related to Institute of Allianz in Ireland; Due to this fact that the building design and construction in each country is unique, therefore, they do not seem to be used in other countries.

In general, research literature review indicates that items concerning fire safety are general and comprehensive; Therefore, in mentioned research, there are very small specific safety instances against fire which have been discussed, however, today the safety measures have exceeded the fire extinguishers.

According to the studies based on buildings fire safety status, not much attention is attracted to dormitories. In studies that determine the buildings fire safety status, non-residential, office and treatment buildings have been assessed more than the other buildings and student dormitory buildings have not been mentioned. It is important to note that the fire department did not pay attention to dormitory buildings and have not considered the rules for these buildings. Even the supervising organizations to the dormitory building constructions, have not taken this into account.

Based on the present study findings, tables and charts, existing standards and chart analysis, it can be concluded that the Zanzan University of Medical Sciences dormitories are not safe against fire for several reasons. According to the established criteria, dormitory buildings lack a decent resistance against fire, and have shortage of automatic alarm systems warning signs and exits, and portable extinguishers.

In most studies, designing the data gathering tool and determining the validity and reliability, is time-consuming and expensive .If valid and

reliable scales are available in a variety of topics, the process of study will be accelerated and the costs will be reduced, and reworks avoided. Besides, existence of a valid checklist facilitates inspections and reduce the confusion of possible risk factors. It seems that suggested checklist is an effective step to this aim.

Limitations

This study was conducted only in the boys' dormitories of Zanzan University of Medical Sciences. However, it could be staged in other dormitories. Also, due to the lack of standards and specific instructions for securing residential buildings against fire, the researchers aggregated multiple sources were used to design the checklist; which can reduce the necessary connection between the tool and the research environment.

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*Appendix**The amount of CVR, judgments numerical average and results of acceptance or rejection of items.*

| Row | Item | CVR | Judgments numerical average | Acceptance or rejection |
|-----|--|-------|-----------------------------|-------------------------|
| 1 | Are there emergency exit routes in case of fire in the building? | 0.20 | 1.6 | Accepted |
| 2 | Are dormitory residents having access to exit options easily? | 0.60 | 1.8 | Accepted |
| 3 | Are the exit ways directed to secure locations inside or outside the dormitory building? | 0.60 | 1.8 | Accepted |
| 4 | Do the exits not lock? | 1 | 2 | Accepted |
| 5 | Are stairs and emergency exits, exist in sufficient numbers and with appropriate capacity and Proper opportunity? | -0.20 | 1.4 | Rejected |
| 6 | Are there at least two separate and far from each other in each floor in building? | 0.60 | 1.8 | Accepted |
| 7 | Do stairways and emergency exit have appropriate capacity? | 1 | 2 | Accepted |
| 8 | Are there appropriate dormitory building emergency exit routes (in terms of dimensions and size)? | 0.60 | 1.8 | Accepted |
| 9 | Are there adequate lighting, natural or emergency in hallways, stairs and outputs? | 0.20 | 1.6 | Accepted |
| 10 | Are there emergency lights in dormitory's exit options? | 0.60 | 1.6 | Accepted |
| 11 | Are there clean from obstacle, object or accumulation furniture in access routes, escape steps and outputs? | 0.60 | 1.8 | Accepted |
| 12. | Are emergency exits marked with boards? | 0.60 | 1.8 | Accepted |
| 13 | Do emergency exits have specific panels so easily visible from a distance? | 1 | 2 | Accepted |
| 14 | Are the multi-story buildings steps and their skylights made from fire-resistant materials (dyes or thin sheet metal or a layer of plaster)? | 1 | 2 | Accepted |
| 15 | Are the all emergency exits marked with an exit sign and illuminated by a reliable light source? | -0.20 | 1.2 | Rejected |
| 16 | Are there exit doors having at least 80 cm useful wide? | 0.60 | 1.8 | Accepted |
| 17 | Are there enough outlets to provide right away in emergency situation? (According to the number of people in the building) | 0.20 | 1.4 | Accepted |

| | | | | |
|----|--|------|-----|----------|
| 18 | Are there the exit ways doors having at least two meters high? | 1 | 2 | Accepted |
| 19 | Are the all doors, passage ways and staircase (that are not emergency exit, but may be confused as a way out) marked properly? | 0.60 | 1.8 | Accepted |
| 20 | Are dormitory emergency exit stairs lacking spiral or screw? | 1 | 2 | Accepted |
| 21 | Are there used from fence next to the stairs? | 0.60 | 1.8 | Accepted |
| 22 | Do fire extinguishers have a safe shut down? | 1 | 2 | Accepted |
| 23 | Do fireboxes have a distance up to 20 meters of each other? | 0.60 | 1.8 | Accepted |
| 24 | Are extinguishers are installed at the proper height? | 1 | 2 | Accepted |
| 25 | Are the fire extinguishers have expiry date and charge date? | 1 | 2 | Accepted |
| 26 | Are the fire extinguishers installed in the right place (in terms of access) in the dormitory building? | 1 | 2 | Accepted |
| 27 | Are the fire extinguishers in protect against rust (in a dry place away from moisture)? | 1 | 2 | Accepted |
| 28 | Are dormitory residents familiar on how to use fire extinguishers and operations? | 0.60 | 1.8 | Accepted |
| 29 | Are there use other fire protection equipment except fire extinguishers? | 0.60 | 1.8 | Accepted |
| 30 | Are all fire-related equipment such as fire extinguishers, fireboxes and etc. periodically assessed? (Check visit card with historical period) | 0.20 | 1.6 | Accepted |
| 31 | Are extinguishers consumed being replaced immediately? | 1 | 2 | Accepted |
| 32 | Is the access to fire extinguishers easy? | 0.60 | 1.8 | Accepted |
| 33 | Is there manual fire alarm system (siren keys) in the dormitory building? | 0.20 | 1.6 | Accepted |
| 34 | Are all fire extinguishers placed so that not blocking the way in times of disaster? | 1 | 2 | Accepted |
| 35 | Is the computer site equipped with fire extinguishers of carbon dioxide? | 0.60 | 1.8 | Accepted |
| 36 | Are the sprinkler installed in the kitchen, library and computer site? | 0.60 | 1.6 | Accepted |
| 37 | Is the wiring of electrical installations Inspected by a competent person periodically? | 1 | 2 | Accepted |
| 38 | Are the dormitory building coated wires (in fire risk environments) passed far from damage? | 0.60 | 1.8 | Accepted |

| | | | | |
|----|---|-------|-----|----------|
| 39 | Are flammable coating equipment and procedures are in safety condition? | 1 | 2 | Accepted |
| 40 | Are all electrical equipment such as switches, sockets and etc. safe on the walls of the dormitory? | 0.20 | 1.6 | Accepted |
| 41 | Are there healthy and fit fuse power way? | 1 | 2 | Accepted |
| 42 | Are there connector using to create a split in the outlet? | 1 | 2 | Accepted |
| 43 | Are dormitory residents not using from heating appliances and electric heaters for heating their rooms? | 1 | 2 | Accepted |
| 44 | Are all heating appliances in dormitories building, safe? | 0.60 | 1.6 | Accepted |
| 45 | Is the emergency generator in dormitories powerhouse, properly secured in place? | 0.60 | 1.8 | Accepted |
| 46 | Is the installed electrical equipment maintenance as well? | -0.20 | 1 | Rejected |
| 47 | Is dormitory building wiring, in accordance with the technical principles? | -0.20 | 1 | Rejected |
| 48 | Are boilers tested in term of hydrostatic once a year? | 1 | 2 | Accepted |
| 49 | Are the pipe fittings, flanges, valves, etc. are installed firmly in place? | 0.60 | 1.6 | Accepted |
| 50 | Is the entrance of powerhouse suitable for exit emergency exit too? | 1 | 2 | Accepted |
| 51 | Are transformers fixed properly to the floor or wall? | 1 | 2 | Accepted |
| 52 | Are hot and cold water pipes, hot water back and sewer pipes, inhibited? | 0.60 | 1.8 | Accepted |
| 53 | Do the pipes at the junction of the boiler have a flexible fittings? | 1 | 2 | Accepted |
| 54 | Are hot and cold water pipes, steam, gas and diesel has standard color? | 0.20 | 1.6 | Accepted |
| 55 | Are dormitory powerhouse electric cables far from the gas, steam and water tubes? | 0.60 | 1.8 | Accepted |
| 56 | Is the boiler having at least 90 cm away from the ceiling? | 1 | 2 | Accepted |
| 57 | Are the boilers were constantly in the right place? (So is resistance to vibration) | 0.60 | 1.8 | Accepted |
| 58 | Are the water heaters restrained to wall or ceiling? | 0.60 | 1.8 | Accepted |

| | | | | |
|----|--|-------|-----|----------|
| 59 | Are powerhouse distributions pumps inhibit and resist vibration as well? | 1 | 2 | Accepted |
| 60 | Do the boilers in the water inlet have a special valves to turn off the boiler in water outage or in high pressure or temperature? | 0.20 | 1.6 | Accepted |
| 61 | Are there installed the plate profile on the boiler? | 0.60 | 1.8 | Accepted |
| 62 | Are the fuel tank place so that its distance from the nearest torch is at least 5-6 meters? | 1 | 2 | Accepted |
| 63 | Are interior and exterior of powerhouses not used as storage room for consumer goods or scrap? | 0.60 | 1.8 | Accepted |
| 64 | Is the burnt waste collected as well? | 0.60 | 1.8 | Accepted |
| 65 | Are appropriate firefighting equipment is available? (The carbon dioxide) | -0.20 | 1.4 | Rejected |
| 66 | Is there manual or automatic system to the gas outage on time? | 0.60 | 1.8 | Accepted |
| 67 | Is there manual or automatic system to water outage on time? | 1 | 2 | Accepted |
| 68 | Is there manual or automatic system to Power outage on time? | 0.60 | 1.8 | Accepted |
