A Novel Evaluation of Fire and Safety Management Scheme in Electronic Components Manufacturing Industry

M.KAMALAKKANNAN[1], Dr.S.SATHISH[2].,
[1,2] Industrial Safety Engineering, Department of Mechatronics Engineering,
K.S.Rangasamy College of Technology, Tiruchengode, Namakkal, Tamilnadu - 637215.
E-mail: kamalgmga@gmail.com, sathishs@ksrct.ac.in

Abstract—Any structure, whether residential or commercial, institutional or public, can experience a fire at any time. This is safe to assume that any industrial environment might be severely affected by fire, both in terms of human safety and loss of materials. Protection from fires and their causes is not a difficult task. The rules for preventing fires are elementary and widely known. However, efficiently dealing with fire situations is not always an easy thing. Continuous vigilance is required to guarantee these procedures are properly applied on a daily basis, as well as careful thought of the dangers of our activities and the creation of efficient strategies for dealing with these dangers. The basics of fire safety and security in the electronics components manufacturing sector revolve around the steps taken to both prevent and respond to fires. Developing reliable fire safety infrastructure in India is an area that needs more work. Systems should be built with worker and property security in mind to guarantee reliable operation. Fire detection systems, fire alarm systems, a comprehensive fire prevention plan, and the implementation of all applicable legal requirements pertaining to fire and safety management are all essential components of an effective fire protection and preventative maintenance programme in the Electronic Components Manufacturing sector. This paper describes clearly about the factors that rise the fire risk scenarios and providing the suggestions to avoid those situations as well as in any case if it occurs, this research provides an option to deal with that in an intelligent manner.

Keywords—Safety Management, Fire, Electronic Manufacturing Unit, Prevention, Fire Protection

I. INTRODUCTION

Security measures to avoid fires are straightforward. Preventing fires by adhering to certain fundamental guidelines is common knowledge and easy to put into practice [1]. Fire emergencies may be difficult to deal with. Thinking through the potential risks of daily operations, formulating sound plans to mitigate those risks, and maintaining a vigilant eye on their implementation are all essential. Protection measures against fire in factories producing electronic components typically consist of standard operating procedures for fire detection and suppression. India still has a long way to go before it has fully implemented fire safety infrastructure. Systems should be built with worker and property safety in mind to guarantee secure operations. The use of a fire detection system, a fire alarm system, a fire prevention strategy, and the application of legislative requirements for fire as well as safety management are all essential for ensuring the safety of workers in any industry that produces electronic components.

While fire is a natural part of our environment, it also has the potential to create tragic mishaps leading to damage via its exothermic chemical process of combustion, which releases heat, light, and numerous reaction products. India recorded 11,037 fire incidents in 2019, which is 16% fewer than the previous year. Despite the government's efforts to reduce fire accidents and deaths via regulation of risk and management, improvisation is essential to maintaining a sustainable strategy. Most fire mishaps, which often have tragic outcomes, occur in buildings. Therefore, the government as well as fire safety rules are establishing a variety of measures in buildings with the express purpose of reducing such injuries as well as property loss. Plastics, long-lasting materials, and insulation solutions are only a few examples of the new building technology and materials being extensively employed to upgrade safety standards. The most important aspect of fire safety is having a way for people to get out of the building, as well as having working smoke alarms, heating, ventilation, and air conditioning systems, and other fire suppression

measures [2]. There is a growing need for innovative and environmentally friendly solutions to the problem of fire safety in modern high-rises. The building industry has made great strides in improving the safety of structures and the people who inhabit them via the use of suitable Electric systems, ventilation, and coating materials. Fires have broken out in India recently, and there are a variety of possible situations that must be examined, each with its own set of strengths and weaknesses.

The administration will be solely liable for the upkeep of all fire safety features, including means of egress and active fire protection systems like portable fire extinguishers, emergency lighting facilities, warning systems and an instruction manual for employees in accordance with Indian regulations. The following was essentially covered: making ensuring a safety management strategy is in place for the facility is essential for carrying these things out properly. Issues pertaining to:

- Fire extinguishers must undergo periodic inspections, reviews, and maintenance.
- The contractors are now operating within the premises.
- What steps need to be taken if there have been renovations to the building.
- The Protocols for Emergencies (including evacuation management).
- Regular checks and safety measures.
- How to reduce the frequency that the fire alarm sounds.
- Fire system commissioning and handover, fire safety handbook
- Instruction for the workers.
- What everyone on staff is responsible for in the event of an evacuation.
- Improvements and enlargement.
- Fire drills and the manual's status will be tracked and evaluated.
- Responsibilities for conducting fire risk assessments.
- Exceptional occurrences need unusual methods of execution.

A. Function of Fire Safety Managements

Management of fire safety has three primary functions:

- It's important to keep the fire extinguishers and other safety equipment in working order.
- During a fire emergency, steps must be taken to preserve lives and get people to safety.
- Existing safety measures should be examined and updated if there is a change in building, change in usage, or new technologies in fire services installations.

B. Hazards and Effects

The term "fire hazard" refers to any potential source of a fire or any action, substance, or situation that might raise the size as well as severity of an existing fire [3]. The threat might come from a readily combustible fuel or a source of heat, such as a broken appliance. Only 6% of fires start with the combustible or flammable gas or liquid, pipe, or filter, yet these components account for 31% of casualties as well as 12% of direct property damage. Aside from deliberate ignitions, the following are the most prevalent causes of fires in the electronics components industry:

- Lighting and Electrical
- Fires caused by trash and garbage
- Fires caused by overexposure
- Combustible liquids/highly flammable materials.

(i) Lighting and Electrical: Historically, electrical fires have been caused most often by faulty wiring, cables, and other associated equipment, followed by lights, bulbs, and illumination [4]. Transformer fires and flames caused by other electrical outlets, cables, and plugs are included here as well. According to the NFPA, electrical distribution as well as lighting equipment fires was the second greatest cause of fires in the United States. As well as starting flames and directly contributing to property damage and civilian casualties, electrical failure as well as malfunction was the major cause of

fires. In reality, the majority of human casualties were caused by electricity and lighting systems.

(ii) Fires Caused by Trash and Garbage: According to the NFPA report, there are around 170 garbage and waste fires annually. Unwanted packaging trash may soon become a major problem in today's vast distribution centers due to the high volume of products stored there. One of the most effective means of reducing waste is via properly educating staff. Over the last decade, approximately 170 fires have been ignited by trash and garbage, making it imperative to instruct staff on proper garbage disposal procedures. Waste materials left alone might spark a fire or obstruct escape routes [5]. Maintain a clutter-free environment by using proper garbage management procedures and always clearing a path to the exit.

(iii) Fires Caused by Over Exposure: Due to another fire outside, the building's flames are exposed to the elements. A total of 7% of distribution centre fires and 7% of annual direct property damage ($11 million) were caused by exterior exposure fires, according to the NFPA report. The surrounding environment may contain cars, trees, and other plants and structures. These fires are especially perilous since it might take a long time for firefighters to find the source of an exterior fire depending on factors like their location and the effectiveness of their detection equipment. Because of this, it is crucial to put out cigarettes fully and dispose of them in a sealed container meant for them rather than throwing them on the ground or even in bushes, and to keep flammable objects away from outdoor electrical outlets, cables, and hot lights.

(iv) Combustible Liquids/Highly Flammable Materials: Extreme dangers are present in most distribution and e-fulfillment facilities due to the use of gas lines, liquefied gas, or propane in heating and cooling systems, forklifts, motors for overhead doors, vehicles, and other equipment, kitchen appliances, and in certain instances, tools and outdoor appliances. When exposed to a spark or open flame, gases as well as other flammable liquids may burst into flame immediately.

C. Effects

(i) Fire Effluents in the Air: Combustion byproducts will be carried upward by the fire plume's buoyancy, from whence they will spread according to the direction and strength of the wind. Emissions of harmful and ecotoxic species, such as inorganic gases, volatile organic compounds (VOCs), polycyclic aromatic hydrocarbon (PAHs), as well as dioxins, have been shown to be common in plumes. The species carried up by the plume will be small and light. The contents and vulnerability of the receptors provide the greatest threat from these gases. Particulates, such as smoke and soot, are typically released during electrical fires. While the general population may not be adversely affected by these particles, persons with asthma or the elderly may be at risk.

(ii) Fire Effluents in the Water: Fires have been proved to have severe impacts on water supplies, as shown in the city of Basel, Switzerland. Most fires can be put out using water, however additional chemicals (such as surfactants or foams) may be utilized. The run-off might potentially migrate and damage a nearby natural water flow if adequate containment and treatment are not performed. Water may carry many substances and potential contaminants to their point of origin because of their solubility. Besides volatile organic compounds (VOCs), Polycyclic Aromatic hydrocarbons (PAHs), hydrocarbons, dioxins, metals, ammonia, as well as suspended particles, the fire effluents of any of the items that a building or industry has on-site are one of the most non-specific effluents.

(iii) Fire Effluents in the Terrestrial Environment: There is less immediate danger from fire's impacts on the terrestrial ecosystem, but there may be longer-term exposure issues. Both the plume itself and the land below it may serve as supplementary pathways for the effluents to reach the terrestrial ecosystem. Effluents will need to be identified, and one of the first steps in doing so is figuring out whether there are any extinguishing agents or dangerous items on the premises.

II. RELATED STUDY

Mohsen-Bezenjani et al., 2021 [6] proposed a paper suggesting that Cities, homes, and businesses are still being lost to fires all over the globe. When a fire breaks out in an environment the danger increases dramatically. In order to enhance fire safety in tall buildings, an innovative Internet of Things (IoT) architecture is presented in this paper. Since smoke inhalation is the leading cause of mortality in a fire, the suggested five-layer design is intended to make safe evacuation easier. In addition, our IoT framework identifies and sends the precise locations of any trapped people within the structure. In order to analyze the decision-making layer of the Internet of Things architecture in the Marseilles, France high-rise "La Marseillaise," software is created in the "Python 3" programming language. Using machine learning methods like Artificial Neural Network (ANN) as well as Support Vector Machine (SVM), this software is able to accurately categorize the various areas of "La Marseillaise" based on the toxicity of the smoke to a rate of 98%. The smoke extraction system receives its instructions from the software based on this categorization, and it increases ventilation in high-risk areas to lower the risk of people suffocating.

Teodosi-Tsankov et al., 2021 [7] proposed a paper suggesting that natural gas is used for a significant portion of the Republic of Bulgaria's industrial and residential energy needs because of its low price, ease of operation, etc. Despite the growing need for and availability of gas, operating gas infrastructure comes with significant dangers to people's lives and property from accidents and fires. Electrical causes of potential mishaps need further scrutiny.

Duma et al., 2021 [8] proposed a paper stating that accident analysis as well as risk management are crucial parts of any programme aimed at reducing workplace mishaps. Finding the root causes of industrial fire and explosion incidents and providing solutions to avoid them were the goals of this study. Eighteen (18) papers from 2015 to 2020 that were examined by experts were included in this systematic literature review. According to the findings, fire and explosion mishaps in the petrochemical sector are the consequence of a number of factors; nevertheless, human error, a lack of understanding, and improper implementation of laws were commonly noted as important reasons. A dedication to safety culture, understanding of hazards and risks, risk management, and learning from past experiences was determined to be effective mitigation techniques for reducing accident occurrences based on the identified reasons. The research made a contribution by determining what factors lead to fire and explosions, and it also suggested measures that might be taken to reduce the danger.

Hartmut-Surmann et al., 2021 [9] proposed a paper relating that the objective and lessons learned from the survey of a Berlin factory hall containing hazardous compounds after a devastating fire are the subject of this technical report. Only unmanned aerial vehicles (UAVs) and cameras were employed to survey the area and document the structure throughout this operation. To begin designing the foyer's entryway, a geo-referenced 3D model of the structure was constructed. The UAVs were then utilized to photograph the hall's extensively damaged interior from above. The region around the UAV was mapped out by using photos captured by a 360-degree camera positioned below the vehicle. For the purpose of generating a 3D model and overviews, the acquired data set was cleaned of subpar photographs by means of visual SLAM, bundle correction, and blur identification due to the presence of duplicates and fuzzy images. Evidence was presented showing that the emergency services were unable to properly interpret the 3D model. In order for rescue workers to see what's going on, we created a panoramic viewer that can connect to other 360-degree photos based on the visual SLAM algorithm's semi-dense point cloud and camera placements.

Chirag et al., 2021 [10] proposed a paper suggesting that the purpose of this research is to analyze current methods of fire protection and their use in buildings, since these are the methods mandated by current technology. High-rise building fires, the Covid-19 hospital fire, and a managerial comparison

to other industrialized nations' systems are all presented as case studies. However, unfavorable weather events are taken into consideration, and many ways to lessen their impact are under evaluation. Those structures' designs and the precautions they have taken to prevent fires. Information was gathered from periodicals and relevant materials; implementing these recommendations is anticipated to be a significant improvement over previous study. It is also crucial to educate residents on the fire safety procedures they should follow in the case of a fire as well as other fire prevention strategies. The research analyzed the organizational structure, reaction times, and management that have to be educated in urban and rural cities in India for the efficacy of these measures.

III. CONTROL MEASURES

The following are important considerations when choosing a fire detection system. In most cases, fires begin modestly and spread slowly, making early detection of the problem crucial. A fire alarm and detection system that sounds an early warning is a crucial safety feature. It is important to consider the likely types of fires while selecting detectors for a fire detection system.

A. Heat Detectors

These are activated by the converted heat from a fire and are often installed on it or near the ceiling. In order to function, heat detectors must detect a change in the physical or electrical properties of a substance or gas at a certain temperature. The ideal places to employ heat detectors are in enclosed areas, since the heat produced by even a single little fire may disperse quite quickly.

B. Smoke Detectors

Since smoke does not disperse as quickly as heat occurs in an open area, these systems are more suited to protecting such areas. Smoke detectors are often placed in a grid pattern or according to the direction of the airflow. According to their respective working mechanisms, smoke detectors may be divided into three broad categories: Radiation in the detecting chamber of an ionization smoke detector ionizes the air there. Because of this, electricity may flow freely between two positively and negatively charged electrodes. This smoke alarm works well in areas where intense flames are possible. Low-temperature pyrolysis as well as PVC wire insulation may cause flames, however photoelectric smoke detectors/optical smoke detectors can detect these fires. They use a light obscuration device or the light scattering theory to find the fire.

C. Flame Detectors

The flame detectors work best in environments with potentially explosive or combustible dust, fumes, or vapors. They are sensitive to wavelengths of light between 4000 and 7700 A °, which are either outside or beyond the range of the human eyesight. To detect infrared flames, a photovoltaic as well as photo resistive cell is coupled with a filter to exclude undesired wavelengths from the incoming light, and a lens to concentrate the light on the cell. Flame flicker in the range of 5 to 30 Hz, as well as the whole IR component of flame, may trigger IR flame detectors.

D. Fire Alarm System

Fire alarm systems become crucial in today's manufacturing facilities due to the prevalence of potentially dangerous situations. Both electronic and electrical fire alarm systems serve the same essential purpose. When the glass of a fire alarm is shattered, the pressure on the knob is relieved, completing the electrical circuit and setting off the alarm. The panel acts as a receiver for the audio/visual signal. Microprocessor, computer based design, Cerberus type of detector as well as shatter glass type of push button devices are often employed.

E. Fire Extinguisher

Fire extinguishers are active fire protection devices used to put out or at least contain minor flames, usually in a hurry. A fire that has spread to the ceiling, poses an immediate threat to the user (no escape path, smoke, explosion hazard, etc.), as well as necessitates the employment of special equipment, people, resources, and/or skill is beyond the scope of this product's intended use.

F. Water Fire Extinguishers

A water extinguisher should only be used on Class A fires. For this reason, you may use a red-coded extinguisher on a fire that has spread to paper, straw, wood, coal, rubber, solid plastic or combustible upholstery. In order to extinguish a fire, water extinguishers shoot water from a nozzle, dousing a wider area. Some include an addition to make the water more effective as well as lower the needed weight and size of the extinguisher; these are a bit more costly but still the most popular and affordable form of extinguisher.

G. Foam Extinguishers

Foam fire extinguishers primarily utilized for burning liquids like gasoline, paint, or turpentine because the foam effectively smothers the fire in these substances (Class A and B fires), but not in burning fats as well as cooking oils (Class F fires). Foam extinguishers, once tested, could be used on certain electrical fires, provided they are fired from at least 1 meter away. They are more costly than water extinguishers and leave a residual that needs to be cleaned off.

H. Co2 Extinguishers

These are made entirely of carbon dioxide gas under pressure and as a result of this, they do not decompose. Carbon Dioxide (CO2) extinguisher is useful in the workplace because they can put out fires involving both combustible liquids (Class B) and electrical fires, such as those caused by big pieces of computer equipment. By smothering the flames, carbon dioxide extinguishes fires without harming electrical components or triggering a system overload.

I. Wet Chemical Extinguishers

Class F oil fires (fats and cooking oils) need special extinguishers, and they are the most common kind used in kitchens with deep fat fryers. Additionally, they are effective against Class A and, in certain cases, Class B blazes. Pressurized alkali salts in water produce a thin mist that extinguishes fires without causing splashing because of the solution's cooling effect, which is costlier than comparable options.

J. Clean Agent Extinguishers

Systems that use clean agents for fire suppression only release gases that are harmless to people and the environment. The installations are recommended for any room with valuables that is regularly occupied (like museums, libraries, data storage centers, and so on). As soon as a fire is discovered, these systems may assist put it out. It consists of R-134a tetrafluoroethane, R-125 pentafluoroethane, and CO2 in the proportions of 60%-80% by volume (CO2).

K. Fire Hydrant System

The backbone of any fire safety infrastructure is the hydrant system, which is both the oldest and most popular method of combating fires. Heavy-duty above- and below-ground pipes, as well as the necessary fittings, are included. All key locations have both external as well as fire escape hydrant valves. A fire hydrant seems to be a pipe connected to a water main and equipped with a valve that may be opened in the event of a fire. It is the purpose of the Fire Hydrant Protection System to put out massive fires across all categories of danger.

It's built to keep working, even if the damaged building falls in certain places.

L. Smoke Extraction System

As shown in Fig. 1, smoke extraction from the fire zone is essential for the safe evacuation of people, the preservation of the building's structural integrity, and the ease of access for fire fighters in the event of a building fire. This helps with visibility, temperature control, and oxygenation of the indoor environment. Extraction fans, a fire damper, fire-rated ductwork, and other components make up a smoke exhaust system.

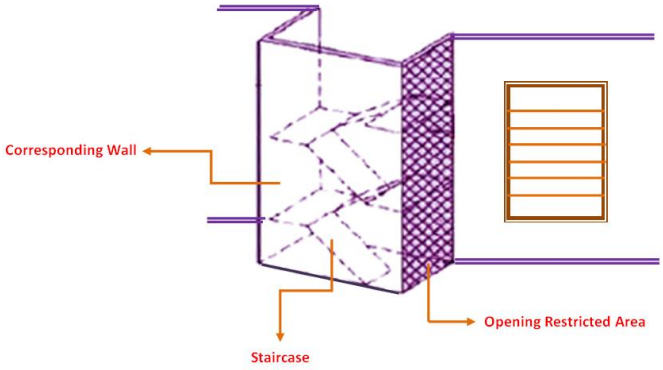


Fig.1 Staircase Wall Opening

IV. DISCUSSIONS

A. Fire Emergency Services and Its Importance

Comprehensive fire management, raising public knowledge about fire safety and implementing in-house fire protection measures in accordance with the National Building Code called NBC. However, most state services lack the directions necessary to effectively implement such legislation. There are now 51 active fire department stations in Delhi's urban areas, one in the city's rural areas and one training facility. According to guidelines, the first fire truck should arrive within five to seven minutes in cities and twenty minutes in rural regions. Current GIS-based study indicates a 51% shortfall. Delhi needs more fire stations to meet the response time standards set by the Standing-Fire-and-Advisory Council.

Based on the Crime Records (CR) and Accidental Deaths and Suicides in India (ADSI) reports, the following table, Table-1 is summarized with proper fire accidents specification, in which it includes the number of accidents occurred, death ratio over the accidents and the injured people ratio over the accidents are mentioned clearly. The same metrics are mentioned in the histogram form over the following figure, Fig-2.

Table-1: Accidents Involving Fires in India based on CR and ADSI Report

YEAR	ACCIDENTS	DEATH COUNT	INJURED
2015	18450	17700	1193
2016	16695	15697	998
2017	13397	13159	348
2018	12057	11280	777
2019	11037	10975	441

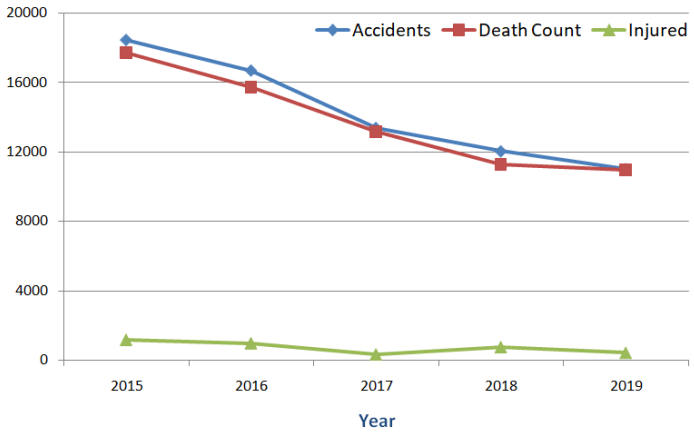


Fig.2 Fire Accident Metrics in India based on CR and ADSI Report

B. The Situation with Present Industries

With the technological breakthroughs that have been made in recent times, preventing fires in high-rise buildings will be an even larger problem. According to National Building Code (NBC) of India, a high rise building/industry is any structure that is at least 15 meters high. Even if the most fundamental safety standards ought to be adhered to, there will still be obstacles to overcome in terms of evacuation tactics, such as

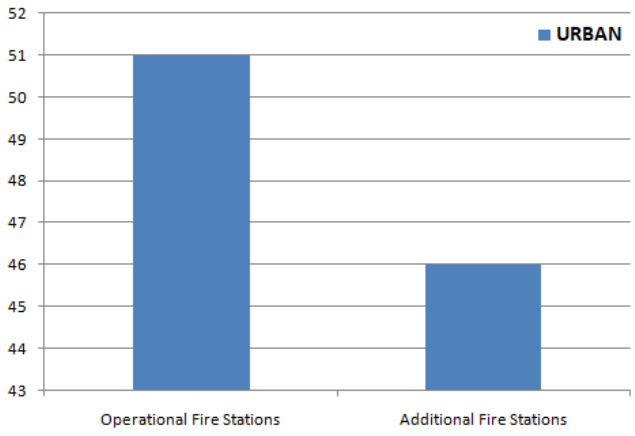
simulated drills and the planning of heat, ventilation and air conditioning systems, etc.

A fire station is required for high-rise properties or buildings or industries because it would otherwise be impossible for fire departments to reach and operate on the building in a safe manner. The term "refuge area" refers to a space within a building that is safe from the effects of fire and smoke and can be used temporarily during the evacuation of the structure. Smoke management includes sealing all gaps between floor slabs and the facade assembly at all levels with an authorized fire-resistant sealant product that has the same fire resistance rating as the concrete floor. This is done to prevent the spread of fire and smoke from one floor to the next. Additionally, there should be air-handling-units on each floor to prevent the spread of fire and smoke through the air conditioning ducts. This provides direction for Emergency Escape indicators that are lit up and hooked into their own separate electrical circuits. The following table, Table-2 illustrates the number of Fire Stations presented in Urban and Rural areas [10].

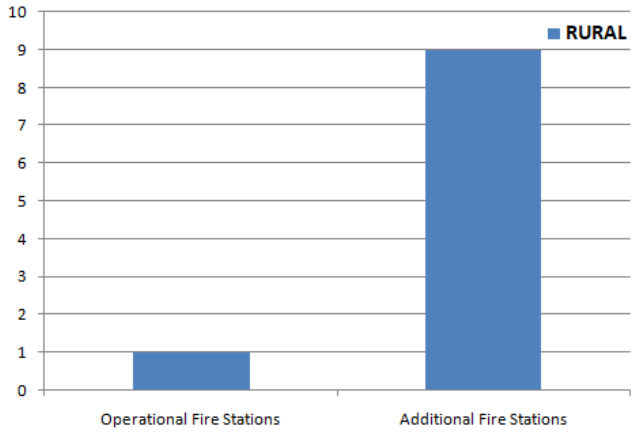
Table-2: Number of Fire Stations in Urban and Rural Areas

URBAN	**Operational Fire Stations**	51
	Additional Fire Stations	46
RURAL	**Operational Fire Stations/Posts**	1
	Additional Fire Stations/Posts	9
	TOTAL	107

The following figure, Fig-3 (a) and (b) provides the histogram representation of the number of fire stations in urban and rural areas, in which the same is mentioned into the table, Table-2.



(a)



(b)

Fig.3 Fire Stations (a) Urban Areas and (b) Rural Areas

V. CONCLUSION

The potential heat indication must be taken into account in addition to the standard storage and transport guidelines, which state that high-value items should not be stored or transported in close proximity to low-value materials (less flammable). Separate the highly combustible components from the pricey ones. More fire extinguishers must be put here and the entrance should be maintained free at all times, not only because of the high danger of fire but also because of the damages that would occur. There must be adequate ventilation and at least a few designated exits in the places where these "high risk" products are stored at all times. As a result of the high combustion rates of these materials, specialized hydrants for quick extinguishing are required in the factory.

REFERENCES

[1] Md. Saiam, Md. Sarower Jahan, Md. Shoab Akther and Md. Nahidul Alam, "A Microcontroller-based Fire Protection System for the Safety of Industries in Bangladesh", International Conference on Information and Communication Technology for Sustainable Development, 2021.

[2] Khandakar Rabbi Ahmed and Md Alomgir Hossain, "An automated IOT Based Fire Detection & Safety Control for Garments industry in Bangladesh: A-Study", International Conference on Automation, Control and Mechatronics for Industry 4.0, 2021.

[3] Yeonjin Kim, Bongseop Park and Gyoungbae Kim, "Introduction to Building and Service of the Fire Safety Big Data Platform in Korea", International Conference on Information and Communication Technology Convergence, 2021.

[4] Peng Li and Li Wang, "Design of Laboratory Fire Safety Monitoring System", IEEE 6th Information Technology and Mechatronics Engineering Conference, 2022.

[5] F.M. Javed Mehedi Shamrat, Aliza Ahmed Khan, Zakia Sultana, M. M. Imran, Abdulla Abdulla and Ankit Khater, "An Automated Smart Embedded System on Fire Detection and Prevention for Ensuring Safety", 2nd International Conference on Smart Electronics and Communication, 2021.

[6] Mohsen Bezenjani, "A Novel Internet of Things Architecture for Improving Fire Safety in High-rise Buildings", IEEE SmartWorld, Ubiquitous Intelligence & Computing, Advanced & Trusted Computing, Scalable Computing & Communications, Internet of People and Smart City Innovation, 2021.

[7] Teodosi Tsankov and Ivan Ivanov, "Gasification of household buildings – technical solutions, European and Bulgarian electrical safety and fire-safety requirements", 13th Electrical Engineering Faculty Conference, 2021.

[8] S. D. Duma, B. B. S. Makhanya and H. Nel, "A Systematic Literature Review on Industrial Fire and Explosion Accidents in the Petrochemical Industry", IEEE International Conference on Industrial Engineering and Engineering Management, 2021.

[9] Hartmut Surmann, Dominik Slomma, Stefan Grobelny and Robert Grafe, "Deployment of Aerial Robots after a major fire of an industrial hall with hazardous substances, a report", IEEE International Symposium on Safety, Security, and Rescue Robotics, 2021.

[10] Chirag, Ankit Kumar, Garvit Jain and Anubha Mandal, "Fire Safety and Management Analysis in India: Review", International Journal of Advance Research and Innovation, 2021.