Various risks and safety analysis to reduce fire in oil refinery plant

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Abstract. It is quite hazardous to produce the final product of oil or gas in a petrochemical refinery plant due to its flammable or combustible and explosive materials. Small mistakes can cause massive damage to life, property, pollution, injury, ecosystem, and business by fire. The entire system is challenging to manage. Therefore, fire risk assessment and forecasting are necessary to overcome personal, environmental, and refinery plants' hazard situations. There have been four main threats in any refinery facility: electrical, mechanical, civil, and chemical issues, maximum cases its result burning. This research aimed to study and assess fire risk in the refinery plant by using a multi-stage early warning system and reducing the fire. The fire hazard safety layer technique would be used for our petrochemical process. Some equipment is set in place to forecast the danger and execution before and after it happens. Geographic information systems (GIS), remote sensing (RS) are some techniques for fire incidents tracking. Flame detectors, heat detectors, and gas detectors are used to maintain good contact in the entire risk analyzer portion. Various techniques and monitoring have been proposed to operate the plant efficiently and safely, like controlling, predicting, and pre-warning strategic planning.

Keywords: Refinery Plant Risk; Fire Reduction; Personal Safety; Plant Safety.

1. Introduction

An oil refining plant is a factory whereby various functions extract various oil types from petroleum products[1]. It's not a simple feature of the refining system. The explanation for the selection of extremely flammable and explosive materials is very complicated. The danger is the most critical issue for an oil refining facility. There are many threats that not only directly but also indirectly occur in oil refining plants. Also, the plant's waste leakage is flammable, explosive, and very dangerous [2]. Any of the waste goes to the river and the atmosphere. It pollutes the river's habitat and water [3]. For all animals living in the atmosphere and rivers, it is hazardous. These are the indirect risks involved. Electrical, electronic, civil, and chemical threats are directly involved [1,4]. There will be firing for these direct threats, and workers may be hurt. The entire plant can even be lost. Some years ago, in China, the

petrochemical firms had fire & explosion incidents [5]. The overall upward trend and situation remained severe, such as the Jilin petrochemical company fire & explosion accident at the benzene factory [5–7]. The heavy casualties and loss of land and a wide area of water contamination in the Songhua River have caused adverse effects in the country and the international community. Petro China Lanzhou Petrochemical Company No.316 Tank Farm Fire and Explosive Accident on January 7th, 2010 [8]. That's why the serial explosion of about eleven tanks one after another. Dalian Dagushan Pipeline Explosion and Fire in Petro-China occurred on July 16th, 2010 [9]. And that is why the Farm No.103 tank fire caused several oil spills and the creation of nearly 60000 square meters of floor flowing fire field, leading to a wide area of water contamination near the Dalian Sea area. Therefore, it is essential to prevent these accidents and protect all things affected by those accidents above or like them, suggesting that some direct and indirect technologies need to be set up. There are various forms of immediate risk use of technology: Monitoring system, voltage control valve, walkie-talkie instead of cell phone, to resolve the electrical risk, the RS system is used. The lubricating fluid measurement scale for regularly checking the amount of lubricating fluid to determine mechanical risk, monitoring the machinery after a period of time and replacing, if necessary post-welding heat treatment, non-destructive heat treatment (UV test, X-ray test, UST test, magnetic test, flange joint, and gasket), heat detector, flame detector, gas detector, etc. [10–12]. It is essential to develop plant-based model to resolve the civil danger. On the actual design and take enough protection, monitoring at a regular time, pre-commissioning test, joint flame test, and GIS. The components of crude oil such as hydrocarbon (CH), sulfur-di-oxide (SO2), sulfur (S) are needed to maintain an acceptable percentage to avoid chemical danger [13]. The waste is re-used as bituminous in liquid form for indirect risk, and gaseous waste is used as a heating source that pollutes the river and the atmosphere.

2. Risk of oil refinery plant

The danger is the likelihood of damage or harm caused by any threat. Adverse effects on humans, plants, or costs are also reported. A qualitative risk evaluation typically includes a matrix of the probability versus the risk acquisition implications from which a risk management decision is made [14]. In oil refinery plants, there are primarily four forms of danger that are followed. Those such as.

2.1. Electrical risk

Most of the machines and equipment in oil refining plants are electro-mechanical and are powered by electrical power. There is, therefore, a greater risk of facing electrical problems. Such as short circuits, networks, high voltage. Shooting is the most likely cause of these issues [15].

2.2. Mechanical risk

An oil refining facility builds many weld joints about 50,000 or higher. So, there is more likely to leak inside or outside the joint for looseness or over the joint's tightness. Increases in high temperature and pressure can result in an explosion. These are referred to as mechanical threats [16].

2.3. Civil risk

The plant is built predominantly by civil design. The soil of the Earth consumes the entire plant load. The plant will break if the soil is not perfect for making the plant because more vibration comes when the plant runs. Any plant is influenced by the environment surrounding it. The bulk of the plant is located next to the river [17]. And in that location, it can face some dangerous storm and Could break the plant. If a plant fails, some problems must be faced, such as if staff may injure or die, production may hamper, and any system may damage, leakage may occur while shooting.

2.4. Chemical risk

Many flammable and active substances are made up of crude and refinery oil, both organic and inorganic. It often produces vapor from liquid organic oil [18]. If the temperature increases, fire is likely.

Sulfur and sulfur dioxide, both flammable and very active compounds, are gasoline's main components. As it is so active, when it goes through it interacts with the pipe and is responsible for eroding the pipe.

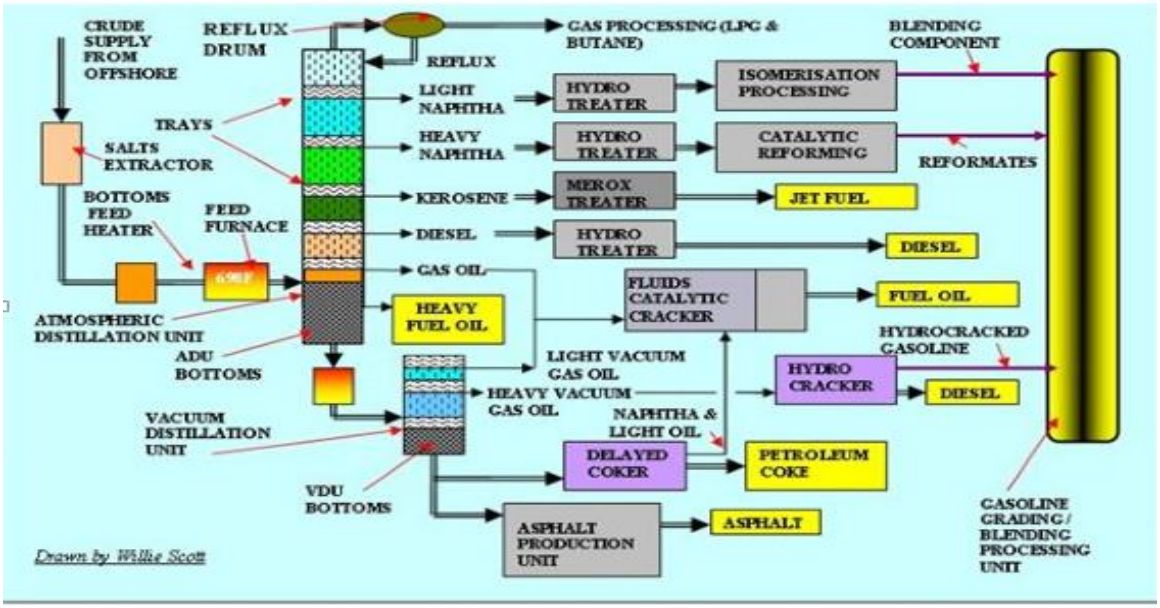

Figure 1. Schematic diagram of oil refinery plant [19].

3. Safety assessment of refinery plant

A person's safety can be described as the depreciation of human-hazard contact and is primarily concerned with the prevention of physical harm (injury) to a person." [20]. Plant safety means 'secure operation of all facilities, safe working people's activities, safe storage of raw materials and goods.' More generally, safety refers to rules and efforts to keep people unharmed, safeguard properties, provide uninterrupted output, and protect the environment in an oil refining plant; there are primarily two types of safety.

3.1. Personnel Safety

Personal Protective Equipment (PPE) is intended to protect personnel from serious accidents or illnesses in the workplace from interaction with chemical, physical, electrical, mechanical, radiological, or other workplace hazards [21]. By providing a shield against workplace hazards, the Personal Protective Equipment (PPE) program intends to protect workers from the risk of injury. Personal protective equipment is not a replacement for sound engineering or administrative controls, or acceptable work practices. Still, it can be used to ensure employees' safety and health in accordance with these controls. Personal protective equipment will be provided, used, and maintained when it is decided that its usage is required and that the risk of a workplace injury or disease will be minimized [22]. Eye, ears, head, foot, and hand safety are discussed in this curriculum. For respiratory and hearing safety, different systems exist.

3.2. Plant Safety

In an oil refining facility, four types of protection systems are primarily maintained.
Electrical Safety: First the supply of electricity is necessary for the operation of any electrical machine. If any issue arises, the production of the plant will initially stop completely. Therefore, adequate electrical protection needs to be provided, such as;

- Electrical supply machinery control.

- Using the Voltage Control Valve.
- Using walkies-talkies for contact instead of mobile phones and so on.

3.3. Mechanical Safety: Most of the machinery in every plant is electro-mechanical, and most of the operating procedures are mechanically handled. In mechanical systems, it is essential to provide protection.

- Using the measuring scale for lubricating fluid and tracking
- The sum of lubricating fluid over a normal period.
- Monitoring for a period and machinery
- Replace it if necessary,
- Ultraviolet test, Xray test, and UST (ultrasonic test: post welding and heat treatment test
- Use the flange joint and gasket to indicate and transfer signal into the control house using the flame detector while the flame is produced anywhere in the factory.

3.4. Civil safety: Construct the plant-based on the actual design and take enough factor safety. There is also a need to monitor the plant regularly, and a pre-commissioning test and a joint flame test are needed. Painting: Near coastal and salty regions, the maximum oil plants are located. There could even be a cement factory next to it. The structure of the plant can be affected by different dust and salt forms. That's why any part of the factory, mostly located in the atmosphere, is painted over.
Wall: If it affects the oil, oil is stored in the tank and can stream over the region and pollute the water. To protect the atmosphere, a wall is constructed around the tank with the same tank volume, and the plant needs to be washed.

3.5. Chemical safety: At acceptable limits, the excess sulfur, excess hydrocarbon, and excess sulfur dioxide are retained. Internal chemical safety: You can extract sulfur by using a catalyst. The removal of hydrogen sulfide is also required. Humans can die if the amount of H2S exceeds 50 ppm.

4. Result and Discussion

4.1. Data collection to risk measurement
A total of 23 samples of data were collected from a reputated Oil Refinery plant of Bangladesh. The data collection was done with two months of observation (July-August, -2019). All data were collected with a written consent form from the industry general manager. From 23 data samples for mechanical lubrication system failure, mechanical device damage and a mechanical short circuit were 162, 272, and 408y. Correspondingly, electrical, civil, and chemical risk are shown in detail in Table 1.

4.2. Data collection on safety measurement
On the other hand, safety measurement data were collected from the same refinery plant, which is shown in detail in Table 2. From Figure 2. (a) it is concluded that, for risk of analyzed data with excess sulfur 13%, lubrication 7%, the system fails 12%, mechanical 18%, device damage 10%, short circuit 4%, high voltage 5% and network 22% respectively. Networking is the topmost risk factor, whereas the short circuit shows the lowest. However, for safety the Figure 3. (b) shows a helmet for head protection 5%, mask for nose protection 13%, hand gloves 4%, safety shoe 5%, detector 24%, foaming 26%, respectively. Table 3 shows the risk, effect, and solution of the oil refinery plant accordingly.

Table 1. Data collection on risk from an oil refinery plant.

Risk Identification	Mechanical		Electrical			Civil	Chemical		
	Lubrication System fail	Mechanical Device damage	Short circuit	High voltage	Network	Constructional	Excess sulfur	Excess So_2	Excess CH
S1	10	10	30	10	10	5	10	10	10
S2	10	10	20	10	5	5	20	10	10
S3	5	5	10	5	5	5	40	10	10
S4	5	10	10	10	5	5	25	10	20
S5	5	15	20	15	5	5	20	5	10
S6	10	15	15	10	5	5	20	10	10
S7	5	10	15	10	5	5	10	20	20
S8	5	10	20	12	3	10	25	5	10
S9	10	10	20	15	5	5	15	10	10
S10	12	20	20	15	2	6	15	3	8
S11	5	10	15	10	3	5	20	18	14
S12	5	8	20	10	2	7	25	8	15
S13	5	10	25	10	5	3	20	7	15
S14	10	15	15	10	2	4	22	10	12
S15	5	10	15	10	3	5	25	12	15
S16	8	12	15	12	5	5	17	12	14
S17	10	12	20	15	3	4	20	6	10
S18	15	20	15	10	5	5	15	5	10
S19	5	10	15	10	2	3	30	10	15
S20	3	10	12	7	3	5	30	15	15
S21	5	10	30	15	5	5	15	5	10
S22	4	10	16	5	2	5	30	10	18
S23	5	10	15	5	5	5	30	10	15
Total	162	272	408	241	95	117	499	221	296

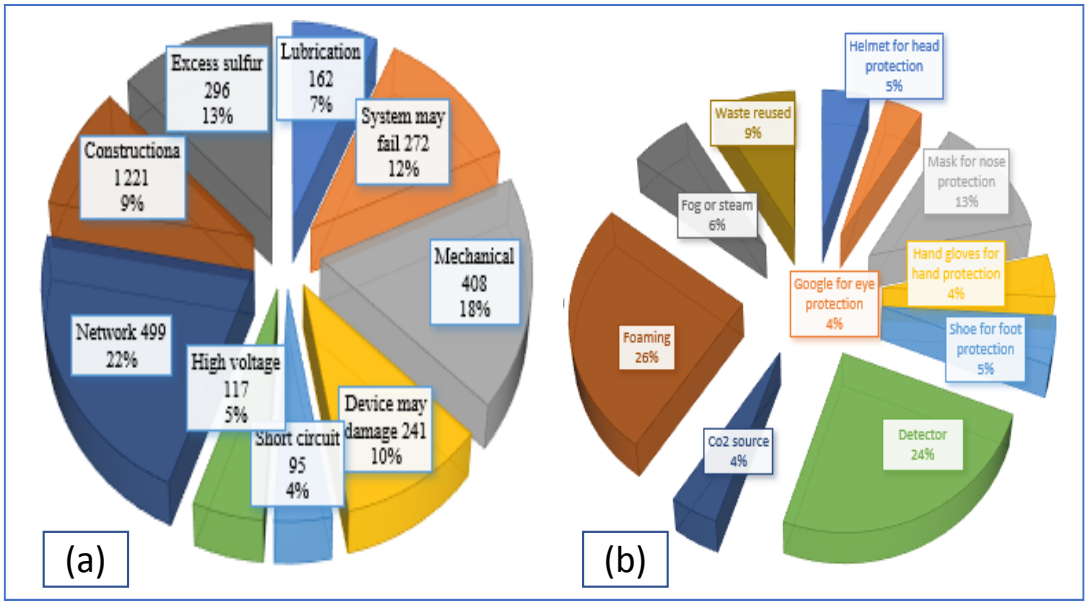

Figure 2. (a) Risk and (b) Safety analysis in the pie chart by percentage.

Table 2. Data collection on safety measure from an oil refinery plant.

Safety provides	Personal					Environmental		Plant		
	Helmet	Google	Mask	Hand gloves	Shoe	Waste reused	Detector	Co_2 source	Foaming	Fog or steam
S1	5	5	10	5	5	9	20	6	25	10
S2	4	2	12	5	5	10	22	5	25	10
S3	5	3	10	5	7	8	25	5	20	12
S4	7	3	15	8	5	8	20	3	25	6
S5	6	4	15	5	6	8	25	5	22	4
S6	5	5	12	5	5	10	22	3	25	8
S7	5	6	10	8	5	4	25	5	28	4
S8	5	5	10	5	5	10	20	5	30	5
S9	4	4	12	4	4	7	27	4	30	4
S10	5	3	15	3	5	6	30	5	24	4
S11	8	3	10	4	5	11	22	4	27	6
S12	5	5	8	3	6	12	25	5	25	6
S13	4	6	12	5	4	10	25	4	27	3
S14	6	3	15	3	5	6	24	3	30	5
S15	5	5	10	5	5	10	22	5	25	8
S16	5	4	12	4	5	11	25	5	25	4
S17	4	3	15	3	5	7	28	4	24	7
S18	5	4	12	5	5	7	30	3	25	4
S19	3	4	16	3	5	10	25	3	25	6
S20	3	3	15	3	3	5	30	3	30	5
S21	5	3	12	3	5	10	22	4	28	8
S22	5	4	18	2	5	11	24	2	24	5
S23	2	2	20	4	3	8	25	4	22	10
Total	111	89	296	100	113	198	563	95	591	144

4.3. Discussion

According to the data collected from the oil refinery plant, some solutions were listed based on the risk in Table 3. Most of the risk in the refinery plant causes firing and huge damage to life and wealth. Proper maintenance and guideline reduce the risk and environmental hazard and increase plant production and efficiency. Providing adequate safety equipment and training is a must for every person related to the refinery plant. Every counter or section should have a checking system for the safety uniform and have a safe assembly point. While the risk alarm will ring, everybody should assemble a safe place and flow in the direction learn by training and not panic.

4.4. Fire hazard prevention and control model

In the case of firing or prevent firing in the plant, the authors proposed a hazard prevention and control model showen if figure 3. The proposed model will be effective and efficient if the plant authority flows accordingly. Saloua et.all [23] used a hybrid technique (HAZID) for identifying the risk scenarios that can result explosion or fire accidents, theirs causes, location and protection measures. They also used PHAST software to simulate and predict the fire.

Table 3. Risk, effect, and solution of oil refinery plant.

Risk		Effect	Solution
Electrical	Short Circuit High Voltage Network	Firing	Monitoring Used Voltage Regulating Valve Used okitoki instead of cell phone
Mechanical	Lubrication systems fail		Used lubricating fluid measuring scale and monitoring the level of lubricating fluid in a periodic time.
	Mechanical Device fail		Monitoring replace period of machinery.
	Temperature Valve Pressure Valve Compressor Pump Engine Function Welding	Temperature rise and firing	Non-destructive heat treatment. Post welding heat treatment, X-Ray test. Magnetic test UST test Flange Joint & gasket. UV Test.
Civil	Construction Fail	Personnel injure or die	Construction based on actual enough safety.
		Device may damage	
		Production may hamper	Monitoring regular
		Firing may occur for leakage	Pre-commissioning flame joint test.
Chemical	Excess Sulphur Excess SO_2 Excess CH	Corrosion in pipe Firing	Reduce it to a reasonable level.

Security management is an interconnected effort that requires leadership for effective implementation and practice at all levels. Employee interest in formulating the organization's safety policy and its role in enforcing these policies in the workplace is of great importance. Participative management is the modern-day philosophy of handling a business concern. A successful safety committee will improve the organization's general safety standards, thereby avoiding injuries. Ultimately, this establishes a greater understanding between employees and managers, less downtime in output, less maintenance costs, consumer confidence, etc. These directly promote the company's competitiveness and profit. More benefit increases the staff's compensation package and welfare activities. A dynamic activity is the development of a thriving safety culture. But the organization must develop a positive safety culture to achieve the best employee results. The safety culture is a delicate entity-it takes time to develop, but if not properly cared for, it can easily be destroyed. There should be a safety & firefighting department, specifically in refinery organizations, to protect.

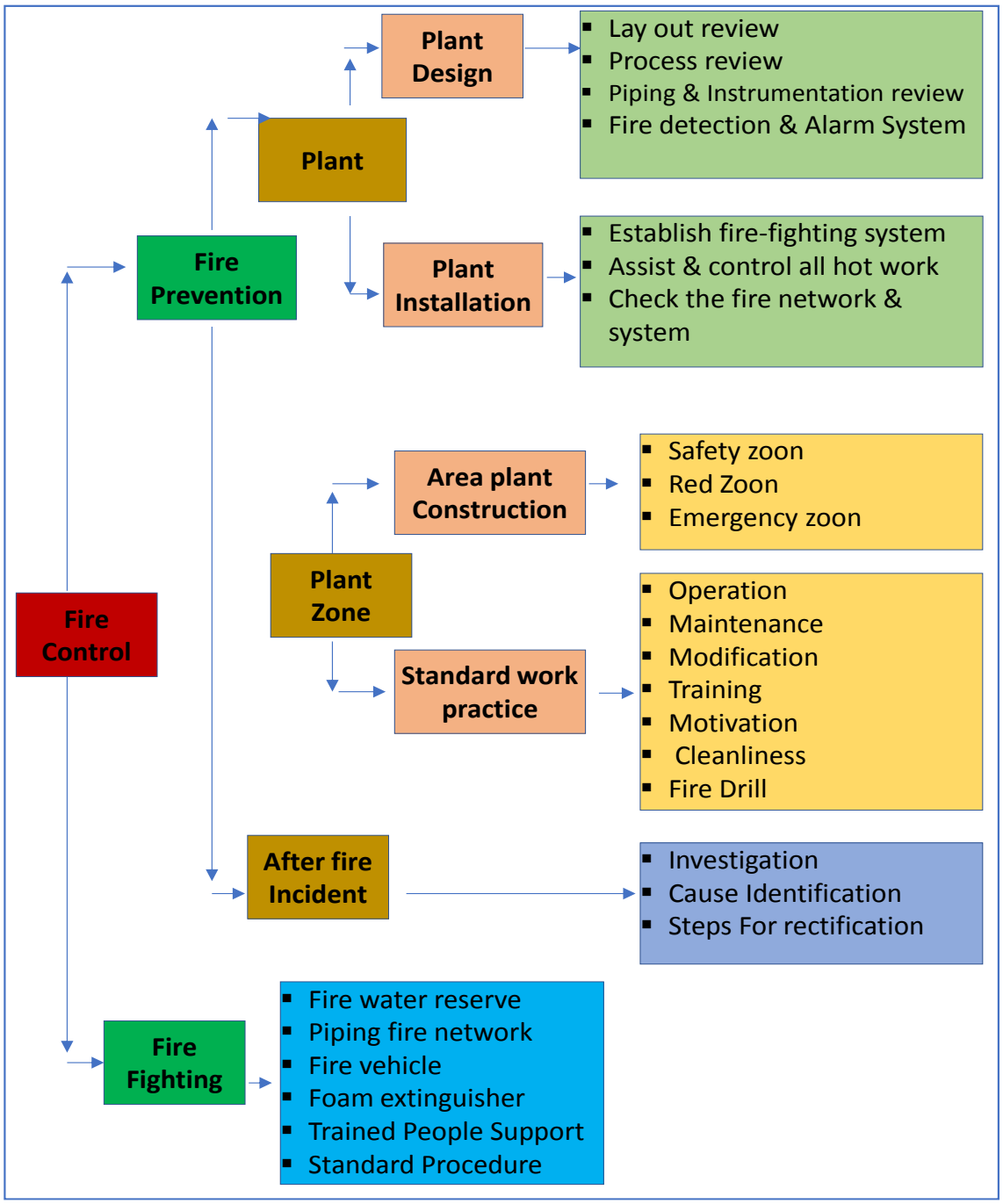

Figure 3. Proposed fire hazard prevention and control model.

5. Conclusion

In both the domestic and industrial areas, fire is a prevalent occurrence. Due to this case, massive losses are suffered by the industries every year. The size-large and operational-critical were rendered by the present design definition of the industries. If not timely and adequately attended, a minor fire incident will end up in the catastrophic form. No unnecessary occurrence of fire, intent, and effort should be made, and if it occurs, timely, and adequately attended. To ensure the facility's proper protection, each industry should have safety regulations, fire control, emergency preparedness & evacuation plan.

In all facilities/companies, the following emergency protocols should be adopted.

- Establish a fire alarm device, sirens, whistles, etc.
- Present written emergency plans in popular positions and provide all staff with copies.
- Maintain direct access to buildings and locations.
- Warn security staff in case of an alarm to open gates/doors.
- Install simple signs in prominent positions, showing fire access route locations, escape routes and extinguisher positions, other combat facilities, etc.

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