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# Study on Fire Protection in Building Services Engineering

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## Abstract

**Despite the extremely low possibility of fire occurrence, fire can be horrible threatens to human life and destructive disasters to architecture and surrounding environment once fire happens. As a result, the requirement for a feasible fire engineering design is essentially to achieve safety standard by not only reducing the damage of property but also providing sufficient time for people to evacuate.**

## Keywords

**Fire protection, building service, wet system.**

## 1. Introduction

The fire protection system in the basement of the Centre of Sustainable and Environmental Technologies (CSET) Building in the University of Nottingham Ningbo, China is a representative example in fire engineering and controlling. By observation and researching of the fire protection in this building, the report focuses on the specification of fire fighting and smoke alarm systems, analysis of system working principles, description of other means of fire protection and suggestions on fire fighting capability improvement.

## 2. Objectives

To conduct a survey and acquire an understanding of the fire protection system (fire fighting system, smoke alarm system and other means of fire protection) in the basement of the CSET building

To develop skills in surveying, analysis and report writing

## 3. Results (Plan Layout and List of Fittings)

The main basement is divided by glass walls into three sections: lobby with exhibition hall, workshop, and lab. Table 1 below shows the quantities and functions of fittings and the photos taken in the target place displays the shape of fittings.

Table 1 Fittings of Fire Protection System

| Fittings in main basement | Quantities | | | | Functions |
|---|---|---|---|---|---|
| | Workshop | Lab | Lobby & Exhibition hall | Total | |
| Smoke detectors | 4 | 8 | 6 | 18 | Detect smoke |
| Sprinklers | 12 | 31 | 19 | 62 | Spray water |
| Speakers | 1 | 2 | 2 | 5 | Inform people of fire |
| Fire extinguishers | 0 | 9 | 3 | 12 | Put out fire manually |
| Manual call points | 0 | 2 | 2 | 4 | Raise the alarm manually |

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| | | | | | |
|---|---|---|---|---|---|
| Exit lights | 0 | 1 | 1 | 2 | Help people evacuate |
| Pipework Support | - | | | | Support pipes |
| | | | | | |
| Fittings in control room | Quantities | Functions | | | |
| Retard Chamber | 1 | Reduce the probability of false alarm | | | |
| Water pressure meter | 2 | Indicate the water pressure | | | |
| Alarm gong | 1 | notify people of fire by loud noise | | | |
| Wet warming valve | 1 | Automatically opens after the sprinklers operate to allow water flow | | | |
| Pressure switch | 1 | Translate pressure signal to electrical signal to control water pressure | | | |

## 4. Analysis and Discussions of Results

### 4.1. Working principles of smoke alarm systems

The smoke alarm system in the CSET building automatically operates when it detects fire. 18 point-type smoke detectors installed in the ceiling are aimed to detect smoke of a fire with a relatively high sensitivity. The detectors are evenly-distributed to guarantee that wherever the fire takes place in the protected area, it can be noticed by these sensors without delay to provide people adequate time to evacuate from the building.

After detected fires, the sounders receive the information from detectors through electrical circuits and generate continuous sound signals to inform people of the occurrence of fire. Since it is an emergency condition, the sound level of speakers should be above the environmental noise. In other words, it can be audibly identified immediately by occupants [1]. At least one speaker is offered in each section in the basement to ensure that all people can hear the warming.

### 4.2. Working principles of fire fighting system

The whole system is traditionally wet installation with one main water supplement in a small room next to the lab. It is appropriate to imply this system because the ambient temperature is lower than 70ºC, suitable for the system [2]. Furthermore, the range of environmental temperature for devices is 4~70ºC, labeled at the surface of device, such as the retard chamber and wet warming valve. The elements watched so far are a water motor alarm gong, a pressure switch, a retard chamber, two pressure gauges, a wet warming valve, sprinklers, pipes with couplings and fittings and pipework supports. Although currently, the wet-form pressure meter (determined by Chinese words labeled on) sited in main water supplement pipe indicates zero and the pipes is empty, once the system is put into service, the gauges will show the water pressure inside due to that the pipes are full of water. In terms of diameter, six different types of pipes are installed in appropriate bonding hanging within the supports of angle steel connected to the ceiling. Table 2 below indicates the diameters.

Table 2: diameters of six types of pipes

| Pipe type | ① | ② | ③ | ④ | ⑤ | ⑥ |
|---|---|---|---|---|---|---|
| Diameter (mm) | 25 | 32 | 40 | 75 | 90 | 100 |

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Observationally, the style of pipework design is traditional 'tree' or 'terminal' system connected by T-joints, cross joints and elbow joints, which means 'the sprinkler heads are fed, singly or in groups, from dead-end range pipes linked to distribution pipes which are fed, in turn, from the water supply through main distribution pipes' [2]. In accordance with the reduction of water flow rate, the pipe directly connected to the water source is widest and the end pipes are narrowest.

Sprinklers are installed along the pipes. The spacing between two adjacent sprinklers is approximately 3.3 meters both in line and in row to provide the even spray to extinguish fires efficiently. These conventional automatic sprinklers with upward heads have an individual heat sensitive component, i.e. a red glass bulb in the CSET building. As indicated in Table 3, the red colored bulb will crack when the head temperature reaches 68ºC. Consequently, the head operates and the inner water under pressure comes out immediately in form of spray to limit the fire growth in early stage. Fire protection water can be interruptedly supplies from the pipes even though the fire has been already put out, until someone switches off the system. Meanwhile, the alarm gong set close to the pressure switch is motive by the flowing water to notify building users though the loud sound.

Table 3: Schedule of color coding of sprinkler heads

| Glass bulb sprinkler | | | Fusible link sprinkler | |
|---|---|---|---|---|
| Temperature (˚C) | Bulb color | | Temperature (˚C) | Yoke arm color |
| 57 | orange | | 55-77 | uncolored |
| 68 | red | | 80-107 | white |
| 79 | yellow | | 121-141 | blue |
| 93 | green | | 163-191 | red |
| 141 | blue | | 204-246 | green |
| 182 | mauve | | 260-302 | orange |
| 227-260 | black | | 320-343 | black |

Nevertheless, sometimes false alarms because of the variation of water supply pressure cannot be evitable. If the system follows the incorrect information and functions as usual, it can spray water to do damage to the building content. To avoid this, the retard chamber (determined by Chinese words carved on the surface of the container), can lessen the possibility of these false alarms by enhancing water pressure in inlet source pipes [3].

The public always have a misunderstanding that when one or a few sprinklers open, they will stimulate rest sprinklers functioning, which is a great waste of water and the system seems not so practical and effective. However, in common case, like the system in the CSET building, the water is only released intensively in the target area from the heads, whose glass bulbs are heated by fire to expand and burst ultimately. Therefore, the sprinkler system can be highly active to a certain extent and utilize the relatively minimum amount of water to eliminate fire.

## 4.3. Other means of fire protection

Apart from the main fire protection system, there is some other equipment or device contributing to fire-fighting and safe evacuation.

An item of ancillary equipment for fire extinction is the red-colored portable fire extinguishers (three in each cupboard) are provided in lab and exhibition hall for people who notice the fire by hearing the alarm or discover it by watching to use before the starting of sprinkler system. According to the Chinese words on the container surface, it is determined to be the dry powder fire extinguishers. However, the notes from Mr. Siegfried K. Yeboah illustrated in his lecture on Fire Protection that with red-coating, the extinguishing agent inside should be water. Thus,

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until now, the information obtained is completely contradictory. However, the fire extinguishers are more likely to be dry powder ones as a result of that the means of classification in China probably is not standard as Yeboah mentioned. Thus, in can brings troubles for users who do not know Chinese. To tackle the problem, it is better to change the color in blue in accordance with the standard and add some in the workshop, which enable people, whatever the language they know, can have an access to fire extinguishers everywhere in the basement (even in workshop).

In addition to smoke alarm system, five manual call points are installed near doors or staircases in the basement (one in lobby, one in exhibition hall, one in corridor and two in lab). They are all combined with the smoke alarm system. In case of a fire, the fragile glass material and the height of the point location (measured approximately 1.4 above the floor) allows people to break it easily to raise the alarm when the smoke detectors have not detect the fire yet [3]. Nonetheless, there are no manual call points in workshop, which cause a great inconvenience. Additional points are necessarily needed.

In the event that the fire cannot be suppressed by the sprinkler system or fire extinguishers, namely the fire is out of control, the best choice is to evacuate to the outside in security. With the assistance of the two exit lights suspending to the ceiling or stuck on the wall in the CSET building, people are able to see the escape route clearly through the dense smoke. However, the number of exit lights need to increase (at least one in each separated section) to permit visual for people in every compartment.

## 4.4. Suggestions for improving the fire fighting capabilities

For firefighting, the wet system certainly has some advantages, for example high rapidity of action. In the meantime, several disadvantages also rise, which should be promoted and developed.

Firstly, during the winter, the environmental temperature sometimes is below zero. The water stored in pipes may freeze and do harm to the pipe structure. In order to improve the performance and capability, alternate wet and dry system featuring anti-freezing can be a favorable solution, since it functions as dry system in cold weather and wet system in warm weather.

Secondly, as mentioned before, the sprinkler head will not stop spraying until someone turns off the switch. The water releasing in this period not only is a waste, but also destroy the furniture. In this perspective, it is not economical and consumes a large quantity of water. Recycling installation, however, can cease and restart in accordance with the information from a newly installed heat detectors in same place, which identify whether the fire is extinguished or re-establish. Consequently, it is an alternative for the CSET building.

Another problem is that the basement is a laboratorial area of the CSET building, hence, the fire hazards can be varied, including hazards of materials and process, owing to the different physical or chemical experiments. But the present system mainly uses water while not all fires can be extinct by water, sometimes even can spread widely with the help of water, such as petroleum-type fire. It is generally believed that fire is supported by three essential conditions, namely heat, fuel and oxygen. If any of them is insufficient, the fire cannot be continuous. Thus, except using water, excluding oxygen is a common method which can extinguish almost fires. Foam installation is one proper choose for solve this problem, as it add an atmospheric foam storage tank and combine the foam flow with water flow to generate appropriate quantity of foam to isolate oxygen from blazing substance [4]. And gas extinguishing system is another more effective installation, commonly use carbon dioxide stored in several cylinders under high pressure emitting to exclude combustion-supporting gas[5].

All the approaches above are fight with fire directly, to improve capability by pressurization in escape route is from another viewpoint of restricting the fire spread. Pressurization can be

identified as 'a form of smoke control using pressure differentials, in which the air pressure in spaces being protected is raised above that in the fire-affected area [5]. Resultingly, by implying mechanical fans in escape route, for instance the corridor open to the outside, to increase the partial pressure, people trapped in fire can evacuate safely through the door with the airflow in instead of smoke flow out [6].

## 5. Conclusion

To conclude, the fire protection system in the basement of the CSET building mainly consist of firefighting system, smoke alarm system with manual call points and portable fire extinguishers. Despite that additional breakglass call points and fire extinguishers are required in workshop, wet installation with sprinklers is covered nearly all the basement and smoke detectors and speakers are fitted at least one in each section. Further consideration also should be taken into account for the purpose of improving the firefighting capabilities. Alternate wet and dry system and recycling system with foam combined and gas extinguishing system are perhaps more suitable for the building due to the occurrence of various fire. And pressurization form can also be applied to assist people to get off the dangerous building. So far, more research and detail information is still demand to know and understand to make appropriate recommendations for improving the firefighting capabilities.

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