

Construction and Research of Intelligent Fire Protection Platform in University Laboratories

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Abstract:

Safety accidents such as laboratory fires in universities still occur from time to time worldwide, seriously damaging the educational and learning environment on campus, and hindering the construction of safe and harmonious campuses. This article summarizes the current situation and prominent issues of fire prevention and control in laboratories in universities, analyzes the application and exploration practices of the current intelligent fire protection system construction, and extends the construction content of a intelligent fire control platform for key laboratories in universities based on intelligent fire protection practice research. The new management model of developing a intelligent fire control platform for university laboratories is based on the current achievements of smart fire protection in society, combined with the risk and hidden danger points of university laboratories and management practices. The system covers laboratory fire safety responsibilities, laboratory fire safety management and supervision, fire equipment and facilities, and laboratory fire safety related personnel. Through the intelligent fire protection platform in the laboratory, all civil defense, technical defense, and physical defense are managed in a closed-loop manner so as to ensure the fire safety of key laboratories in universities.

Keywords:

University Laboratory, Intelligent Fire Protection, Fire Safety

1. Current Situation and Prominent Issues of Fire Prevention and Control in Laboratories of Higher Education Institutions

In recent years, dangerous accidents have occurred frequently in university laboratories around the world. From public media reports alone, it can be seen that laboratory fires and other accidents occur every year. Any laboratory explosion or fire accident will cause irreparable and huge losses to schools, families, and society in various countries. Especially in experiments involving hazardous chemicals, there is a high risk of flammability and explosion. When laboratory personnel mis-operate, failure to follow the process, experiment equipment malfunctions, or natural aging can all lead to explosion and fire accidents from both hardware and software perspectives.

1.1. Current Situation and Problems of Fire Prevention and Control in Laboratory Construction Hardware

World-renowned universities have a long history, with many ancient buildings and a large number of cultural relics. Many of the old buildings have brick and wood structures, and even have all wooden structures. Due to factors such as cultural relic protection and funding, old buildings generally have poor overall fire resistance ratings, and the design of ancient buildings is limited by the times, making maintenance and upkeep difficult. Multiple factors have resulted in a relatively low intact rate of fire protection facilities in old buildings in universities. The renovation is difficult and subject to various factors, but there are still key laboratories in universities conducting scientific research in these old buildings, which poses significant fire safety hazards.

At the same time, universities around the world have gradually experienced a historical period of building expansion and construction. The newly constructed campuses have a large area, diverse buildings, long construction cycles, and multiple factors such as the sharing of fire protection systems between new and old buildings. At the same time, there are also inadequate measures in terms of pipeline anti-corrosion and electronic equipment scrapping and replacement, resulting in a failure to achieve a 100% intact operation rate of the fire protection system. The pressure of the old firefighting pipeline network, the water level of the firefighting water tank, and the working status of the firefighting water pump cannot be comprehensively monitored in real-time. It is difficult to manually supervise and inspect the firefighting facilities, and also difficult to grasp the condition of the facilities. In the event of a fire, the failure of the sprinkler facilities, the absence of firefighting hoses, and the failure of fire extinguishers can also occur, resulting in significant firefighting hazards that cannot work effectively in the event of a fire.

In daily use, there is a problem that the interior decoration of the laboratory building is not designed and constructed in strict accordance with the specifications, and even the foam sandwich panel material is used for partition. This kind of material can be ignited in case of fire, and is prone to produce a large number of toxic and harmful gases. In recent years, fires caused by short circuits or malfunctions in laboratory electrical equipment have also occurred from time to time. In order to save space, the evacuation passageway of the laboratory is not unblocked. For example, for daily security management, anti-theft fences without escape exits are installed on the fire exits, anti-theft windows without escape exits are installed on the outer balcony, and two-way passageways are changed into one-way passageways. In order to facilitate management and meet the needs of teaching and experiments, the fire doors or evacuation passageways of many buildings in the school are often locked or electromagnetic door security are installed by secondary units. And the control of each system is conducted by various secondary units, which leads to the difficulty of opening the evacuation channels and effectively isolating the fire through fire separation when emergency personnel evacuation is required in case of a fire. Escape and evacuation are thus very difficult.

At present, key laboratories in universities store a large number of valuable scientific research instruments, chemical laboratories store flammable and explosive materials, and biological laboratories store highly toxic and controlled reagents, and ultra-clean laboratory sealed environments. Therefore, universities need to have higher requirements for fire management in key laboratories, strengthen the

management of personnel and fire equipment, and ensure the daily fire safety of key laboratories in universities.

1.2. Current situation and problems of fire prevention and control in laboratory construction software

The awareness of fire safety among teachers, students, and staff is not strong enough, such as using illegal electrical appliances in the laboratory, occasional smoking, violating experimental management regulations during the experiment, not wearing protective clothing, not wearing goggles, and leaving the experimental site for a long time during the experiment, which has been a long-standing problem. Currently, many laboratory accidents are caused by students participating in experiments that do not follow the process specifications, or by confusion or operational errors.

At present, the development of universities has entered a fast lane, especially with the continuous expansion of graduate enrollment and an increase in laboratory construction. However, the funding for fire safety is severely lagging behind. The budget for fire safety in most university laboratories is insufficient, especially for projects with high budget funds such as adding fire extinguishing systems to old buildings, which is severely underfunded.

Although most universities have a three-level responsibility system for fire safety, there are still multiple management sectors in these institutions. Fire hazards often arise due to historical issues and the involvement of multiple secondary units, departments, and colleges, which can easily lead to long-term fire hazards that cannot be rectified in a timely manner.

Nowadays, the research tasks of university laboratories are heavy, and the focus of work is mostly on scientific research. The staffing in terms of safety, especially fire safety management, is seriously insufficient. The lack of management and supervision personnel makes it difficult to effectively supervise various safety aspects.

Although most universities attach great importance to laboratory safety, in order to ensure the safe conduct of experiments, regular training will still be provided to teachers and classmates participating in the courses. However, this type of training is actually not a systematic course, which usually skim the surface of the subject. Safety learning is not in place, not timely, and is just a formality.

2. Overall Design Principles of Intelligent Fire Control Platform for University Laboratories

Based on the current status of intelligent fire protection systems available in the market and the prevention and prominent issues in laboratory fire safety work, the author proposes a design framework and future direction for the intelligent fire protection system control platform software in the laboratory. Relying on the construction of the smart fire protection control platform in the laboratory, it is aimed to develop a smart fire protection control system for domestic university laboratories. By adopting advanced information technologies such as the Internet of Things and AI, integrating all six aspects of the smart fire protection system in the market into a system integration to achieve a unified user interface and integrate into a unified system platform for remote real-time control, it not only gives a preliminary real-time early warning of fire hazards, but also facilitates the fire protection work of all

relevant personnel in the laboratory, and facilitates the fire safety responsible person manager to control the laboratory fire safety business and evaluate and analyze big data, while achieving timely closed-loop fire safety management, eliminating fire safety hazards, and preventing fires from igniting before they occur[1]. The following principles are required:

2.1. Platform reliability and progressiveness

It is advocated to adopt advanced and mature computer software and hardware technologies both domestically and internationally to ensure that the laboratory's intelligent fire protection system can adapt to the needs of technological development and business expansion changes in the future to the greatest extent possible.

2.2. Future scalability of the platform

The maintenance of the system accounts for a significant proportion of the entire software lifecycle. The system must fully consider long-term maintenance and future scalability, and can modify certain modules, add new functions, and restructure the system structure according to the school's requirements at any time to achieve long-term program development. In terms of data storage, full consideration should be given to its future development capacity, with maintainability and compatibility to support new applications.

2.3. Comprehensive practicality of the platform

Comprehensive practicality refers to the ability to effectively meet the needs of practical work, allowing users in each link of the laboratory's intelligent fire protection system to maximize practicality and satisfaction. Starting from the actual needs of fire management business, protecting and utilizing existing resources, prioritizing urgent needs, and developing to meet the needs of school laboratory management as the first element, an overall design is to be made with step-by-step implementation of technical solutions [2].

2.4. Platform security and confidentiality

Security and confidentiality are extremely important for the management of university laboratories. Therefore, the overall design is crucial. Multiple measures should be taken to prevent system data from being edited or stolen, and to ensure the secure access, transmission and control of data networks.

2.5. Long term stability of the platform

The entire fire protection process is trivial, so data collected at any time cannot be lost. All data must also be analyzed and processed by AI in a long-term and stable manner. Any data loss or platform failure may bring unpredictable risks to the management of the school laboratory, which requires the platform to have long-term stability. At the same time, data collection and other work should not affect the stable completion of the application of the new system on the basis of the existing automatic fire alarm system platform [3].

2.6. Appropriateness of platform economy

The cost performance ratio is an important consideration factor. When designing, mainstream products and advanced technologies should be adopted in the industry to

extend the system's lifecycle. At the same time, some adjustments have been made based on the existing equipment and applications, making appropriate compromises between performance requirements and investment costs, applicability, and scalability. On the premise of meeting the needs, university management should try to choose cost-effective equipment as much as possible [4] in order to save school funds, maximize efficiency, and complete the system construction with cost-effectiveness.

3. Framework of Intelligent Fire Control Platform for University Laboratories

3.1. Laboratory building fire automatic alarm fusion system

Emphasis will be placed on upgrading and connecting the automatic fire alarm and monitoring systems of laboratory buildings to the grid, and integrate wireless smoke sensing, wireless temperature sensing, wireless cameras and other independent sensing devices in the later stage to achieve intelligent and full coverage of campus fire management. The end stage sensing devices of all fire automatic alarm systems within the laboratory building range and the wireless smoke detectors added by major universities in recent years have been upgraded and integrated. The system can collect real-time and comprehensive information of fire automatic alarm system equipment and wireless smoke sensing signals, and establish data information associations in conjunction with other new fire equipment and even other related safety sensing devices, such as video monitoring information and infrared probes of the monitoring system. It utilizes intelligent analysis methods of multiple types of data information to achieve comprehensive perception and full process monitoring of laboratory safety, integrate and program all monitoring camera signals within the laboratory area with fire alarm points for system integration and linkage. When the fire alarm information reaches the system, it intelligently matches and automatically associates relevant nearby video signals, automatically or manually confirms whether a real fire alarm has occurred in the laboratory area, and generates a disposal association plan to run. The responsible person and disposal person in a timely manner will be notified to reduce losses by the intelligent warning of various potential faults and hazards in fire protection facilities when urging relevant departments to rectify and reduce fire risks [5].

3.2. Laboratory fire water pipe network monitoring system

This includes real-time automatic monitoring of the pressure of the end fire pipe network, water level of the fire water tank, water level of the fire water tank, operation of various fire valves and fire water pumps in the building where the laboratory is located. For example, installing flow and pressure detectors on the fire hydrant and sprinkler official network of the laboratory building, combined with the automatic fire alarm system, can automatically give alarm in case of abnormalities and achieve real-time management of the fire water system. By analyzing big data information, combining with automatic fire alarm fusion system and other ways, the system can find abnormal pressure of fire water system and related fire equipment failures in real time, which can ensure that water is available for firefighting. Thus, it can improve the convenience of inspection, maintenance, and upkeep of the fire water system in laboratory buildings and the work efficiency.

3.3. Laboratory fire equipment monitoring system

The system carried out is mainly optimized for single point data collection of fire-fighting equipment, real-time and effective monitoring and control of the status of fire-fighting equipment in laboratory buildings. For example, all fire extinguishers and gas driven fire extinguishing devices in the laboratory building are installed with intelligent fire extinguisher pressure monitoring devices to accurately monitor the pressure inside the bottles while ensuring that the pressure monitoring methods of fire extinguishers and gas driven fire extinguishing devices comply with relevant laws and regulations. It should always grasp the status of fire extinguishers and extinguishing devices, automatically feedback and issue fire warnings to the system backend when sensing abnormal states such as undervoltage, overpressure, position movement, and temperature. Multidimensional perception of the full lifecycle status of fire extinguishers and extinguishing devices reminds management personnel to handle them in a timely manner.

3.4. Laboratory evacuation channel monitoring system

It is mainly to install a sensing device on the evacuation door of the laboratory. If an electromagnetic door security has been installed, the electromagnetic door switch will be connected to monitor the use status of the fire door of the networking unit in real time so as to ensure that the fire door is in the correct open-and-close state and ensure the use status of the fire door. In daily work, it may not affect the control of electromagnetic doors in each secondary unit laboratory. However, in the event of a fire, it has the function of intelligent automatic cut-off and manual one-click cut-off of all electromagnetic access control power in micro fire stations or fire operation command centers, ensuring smooth evacuation channels.

3.5. Laboratory electrical comprehensive safety monitoring system

In response to the numerous types of laboratories in universities and the frequent use of experimental instruments and equipment, real-time monitoring and early warning of electrical fires have been increased. Intelligent analysis and real-time control of the electrical safety status of laboratory electrical equipment have been carried out, and timely warning and detection of fire hazards in the dynamic operation of electrical circuits have also been carried out. Based on parameter intelligence, the cause of faults can be determined and the abnormal states can be intelligently, automatically and manually powered off to timely eliminate potential electrical fire safety hazards and achieve the effect of preventing non ignition.

For some disciplines in universities, experiments may involve the use of combustible gases, oxygen, or other life-threatening gases, which poses significant safety hazards in fire safety management. In order to ensure the safety of the experiment and promptly grasp the situation in case of accidents, sensors with alarm and intelligent gas cut-off functions are installed in the areas where gas leakage may occur, so as to monitor gas leakage and intelligent gas cut-off disposal in real-time. The relevant equipment must comply with national laws and regulations when the gas detector transmits alarm information to the software platform through the switch interface to achieve remote monitoring and early warning of key laboratory gases.

3.6. Laboratory emergency broadcasting fusion system

It is mainly one of the two important firefighting measures for emergency evacuation of personnel in the event of a fire, which can prompt and guide personnel to evacuate orderly and correctly from the fire passage through sound. The laboratory

fire emergency broadcasting linkage system integrates the fire emergency broadcasting system in the building, mobile phones entering the experimental area, intelligent evacuation signs, and other systems. In case of emergency situations, the building emergency broadcasting system and mobile information push can be used. With the help of the positioning system, evacuation can be carried out in batches and key areas in different buildings. Once a fire or other emergency occurs, the first responder can safely evacuate personnel as soon as possible to ensure the safety of teachers, students, and employees.

3.7. Laboratory grid supervision system

Grid supervision of the laboratory records the quantity, location, inspection, maintenance, supervision, and management information of all fire equipment, fire extinguishers, hydrants, etc. in the campus, and synchronously uploads them to the control platform. The responsibility is assigned to individuals, recording the situation of duty, supervision, inspection, and management. When violations such as missed positions and unsupervised experimental processes are found, automatic video linkage is used to conduct a comprehensive fire safety inspection of the laboratory building comprehensive closed-loop management. In addition, the intelligent taskbar shall remind and send the information to the relevant responsible person in a timely manner. For example, the intelligent maintenance bar can realize the daily maintenance and emergency maintenance of fire-fighting facilities and equipment, ensure the availability of personnel and online monitoring, and greatly reduce the maintenance risk [6]. According to the management responsibility platform, it sends the fire safety manager's mobile phone for matters that cannot be handled and need to be coordinated, and generates a fire safety assessment report for the entire work process supervision information to be sent to the fire safety responsible person.

3.8. Laboratory VR fire training system

The main goal is to customize various types of VR fire training and exercise systems to effectively achieve the goal of standardized behavior, such as immersive escape experiences, fire emergency exercises, etc. At the same time, it can also be applied to the understanding of fire safety equipment and equipment, such as fire equipment usage, human-computer interactive fire games, visual fire system operation, and other fire training. By combining VR technology with campus laboratory fire safety education, teachers and students can be exposed to real fires and face all accidents that occur at the scene of the fire in the most intuitive way, thus enabling them to proficiently master fire escape knowledge in practice.

4. Conclusions

Based on the current practical foundation of intelligent fire protection, and in response to the characteristics of fire safety management in university laboratories, the concept of building a intelligent fire control platform for university laboratories is proposed, providing ideas for the improvement and development of smart fire protection construction in current university laboratories. The platform can enable key laboratory laboratories in universities to establish standardized fire management mechanisms, achieve mandatory requirements from various levels of fire management departments, and reduce the operating costs of university fire protection, Through advanced fire management methods, it can control and intelligently analyze all fire equipment and facilities in university laboratories, as well as daily fire management,

establish efficient early warning methods, achieve early warning and timely and effective disposal of fire and other safety emergencies, reduce the occurrence of fire and other safety issues, achieve refined and comprehensive fire control in university laboratories, and ensure the safety of university laboratories.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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