Research on the Safety Management System of University Laboratories

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Abstract: With the development of higher education and technological innovation, the importance of safety management in university laboratories has become increasingly prominent. The characteristics of laboratories and the traditional safety management model can no longer meet the safety guarantee needs under the new situation, and potential safety hazards and accident risks cannot be ignored. Based on risk management, systems engineering and other theories, combined with literature research, case analysis and comparative research, this paper systematically sorts out the current situation and problems of safety management in university laboratories in China, and proposes a construction path of "prevention first, systematic governance, clear responsibility, and collaborative efficiency". The purpose is to provide guidance for improving the safety management level of university laboratories, ensuring the safety of teachers and students, and promoting the development of higher education.

Keywords: University Laboratories; Safety Management System; Risk Control

1. Research Background and Significance

1.1 Research Background

University laboratories are key places for institutions of higher education to carry out practical teaching and cultivate innovative talents, as well as important platforms to support basic research and cutting-edge technological breakthroughs. In recent years, laboratory safety accidents such as explosions, poisoning, fires, scalds, and bacterial infections have occurred from time to time[1]. In 2009, 5 experimental personnel from a university in Beijing were debugging an anaerobic incubator when an explosion occurred due to unstable pressure, injuring 5 people; in 2013, 5 workers from a university in Nanjing cut a gas cylinder without knowing that it contained oxygen and gas, triggering a gas cylinder explosion, resulting in 1 death and 3 injuries; in 2018, an explosion accidentally occurred when students in a laboratory of a university in Beijing were conducting scientific research experiments on landfill leachate and sewage treatment, causing the tragic death of 3 participating students; in 2021, an explosion occurred when a student was operating a high-pressure reaction in a laboratory of an institute of the Chinese Academy of Sciences, resulting in the death of 1 student. According to statistics, during the period from 1986 to 2019, a total of 150 laboratory safety accidents occurred in universities, scientific research institutes and enterprise laboratories, causing various personal injuries and economic losses. The frequent occurrence of these accidents has exposed the loopholes and defects in the current laboratory safety management, attracting great attention from the whole society. Therefore, it has become an urgent problem to explore the root causes of accidents and formulate corresponding control measures to ensure laboratory safety.

1.2 Research Significance

Nowadays, the safety of university laboratories is facing a new situation with great pressure of safety responsibility, strong awareness of safety and environmental protection, and high requirements for safety and health. In the new era and new situation, the expanding scale of laboratories and the mobility of personnel have made the certain and uncertain factors in their operation more complex. However, various universities still use the original management methods, technical conditions and organizational management structures for management, rather than fundamentally controlling various risks and hidden dangers in laboratories[2]. Therefore, only on the basis of maintaining the unchanged management system and goals of university laboratories, establishing

a full-participation, dynamic and systematic safety management standardization mechanism can we better and effectively ensure the safety of university laboratories[3].

Therefore, by studying the standardized system of university laboratory safety management, this paper conducts a more reasonable and objective research on various possible situations of the standardization of university laboratory safety management in practical applications, which will provide a reliable management system reference for the safety of university laboratories in China from a new perspective.

1.3 Research Content and Methods

Based on the current research status and existing problems, this paper puts forward the following scientific questions: What factors determine and affect laboratory safety management? How to construct a scientific and reasonable laboratory safety management system?

By means of literature research on the safety management of university laboratories at home and abroad, in-depth analysis of typical cases of some universities at home and abroad, and comparison of the differences between the safety management systems of university laboratories at home and abroad, we can not only understand the current research status, but also clarify the current research gaps[4], providing a solid theoretical support for this study, and playing a good guiding role in the construction of the safety management system of university laboratories in China. At the same time, it will also provide valuable reference for how to combine advanced experience with China's actual situation in constructing the safety management system of university laboratories[5].

2. Theoretical Basis and Core Connotation of the Safety Management System of University Laboratories

The relevant theoretical bases of the university laboratory safety management system mainly include: (1) Risk management theory: emphasizing the management concept of "prevention first, full-process control". (2) Systems engineering theory: realizing the optimization and efficient operation of the system. (3) Responsibility ethics theory: emphasizing the moral and legal responsibilities that individuals and organizations should bear in social activities.

The core of university laboratory safety management is to ensure the smooth progress of activities and the safety of teachers and students. Promote the application of risk management concepts through comprehensive risk control, standardized employee management, full participation and continuous improvement. Safety is complex, systematic, preventive and dynamic, involving multiple disciplines, diverse experimental contents and methods, a wide range of dangerous factors, and large risk differences, which require overall planning and collaborative management. Prioritize prevention, identify risks, formulate measures, strengthen education, and improve the level. Dynamically adjust and optimize to respond to changes in a timely manner and ensure better control.

Core objectives of the university laboratory safety management system: The core objectives of the laboratory safety management system include: ensuring safety, preventing accidents, and protecting teachers, students and the environment; standardizing order, establishing scientific processes, and ensuring teaching and scientific research; improving capabilities, enhancing safety awareness and emergency response capabilities; and continuous optimization to realize the improvement and upgrading of safety management work[6].

3. Current Situation and Existing Problems of Safety Management in University Laboratories in China

The organizational structure of safety management in some university laboratories is not sound, and the responsibility system is not fully implemented. There is a lack of professional teams, and safety management work is often part-time by logistics or equipment departments, leading to unclear responsibilities. The safety responsibility system is not perfect[7], the specific responsibilities of each subject are not clarified, there is a phenomenon of "enthusiasm at the top, lukewarm in the middle and cold at the bottom", the accountability mechanism is not sound, and it is difficult to implement management work. Some colleges, teachers and students do not attach sufficient importance to laboratory safety management, leading to irregular operations and potential safety hazards.

The safety management system of university laboratories is not perfect, and the implementation is insufficient. Some systems

are not targeted and operable, and there is a lack of targeted system specifications for the safety management of emerging discipline laboratories and interdisciplinary experiments. Some systems exist in name only, safety inspections and hidden danger investigations are not thorough, and the punishment for irregular behaviors is insufficient.

Risk control capacity is weak, and there are loopholes in the whole-process control. Some universities lack a systematic risk identification mechanism and professional evaluation teams, resulting in insufficient identification of potential risks in the experimental operation process and unscientific evaluation. There are loopholes in the whole-process control, and the management of hazardous chemicals and instruments and equipment has problems of lack of supervision and increased potential safety hazards.

The education and training system is not perfect, and the safety literacy of teachers and students needs to be improved. The content of education and training in some universities is not targeted, the form is single, the coverage is not wide, and the construction of safety culture is lagging behind. As a result, the training content does not meet the actual needs, teachers and students lack emergency response capabilities, and irregular operations occur frequently.

The emergency response system is not sound, and the disposal capacity is insufficient. The emergency plans of some universities are not perfect, emergency facilities are insufficient and improperly maintained, emergency drills are a mere formality, and the emergency linkage mechanism is not sound, making it difficult to adapt to dynamically changing safety risks and obtain professional rescue support.

The level of intelligent management is not high, and technical support is insufficient. Most university laboratories still mainly rely on the traditional manual management model for safety management, lacking a unified intelligent safety supervision platform, insufficient application of monitoring and early warning technologies, insufficient in-depth integration of information technology and safety management, and a shortage of intelligent management talents. This makes it difficult to achieve data sharing and collaborative management, early warning of potential safety hazards, provide scientific support for safety management decisions, and promote the construction, operation and maintenance of intelligent management platforms.

4. Core Components of the Safety Management System of University Laboratories

The university laboratory safety management system is a complex organic system. Based on systems engineering theory and risk management theory, its core components should include organizational structure and responsibility system, system standards and specification system, whole-process risk control system, education and training and cultural construction system[8], and intelligent supervision and emergency response system. Each component is interrelated and mutually supportive, jointly ensuring the efficient operation of laboratory safety management work.

4.1 Organizational Structure and Responsibility System

The organizational structure and responsibility system are the core guarantee of the laboratory safety management system, clarifying the key issues of "who manages, what to manage, and what responsibilities to bear". Its core contents include: First, establish a hierarchical organizational structure and build a three-level safety management network of "university - college - laboratory". At the university level, a Laboratory Safety Management Committee is set up, with the president or vice president in charge as the director, and members including the Department of Academic Affairs[9], Department of Scientific Research, Department of Equipment, Logistics Management Department, Security Department, Student Affairs Department and the person in charge of each college. It is responsible for overall planning of the university's laboratory safety management work, formulating safety management policies and development plans, and coordinating the solution of major safety issues; at the college level, a safety management group is set up, with the dean as the group leader and full-time safety management personnel assigned. It is responsible for implementing the university's safety management policies, formulating college safety management rules, organizing safety inspections and hidden danger investigations, and coordinating the handling of college laboratory

safety issues; at the laboratory level, a safety supervisor is set up, who is the laboratory director or senior teacher. He is responsible for formulating laboratory safety operating procedures, supervising the experimental operation process, conducting daily safety inspections, and organizing laboratory safety training and emergency drills. Second, improve the full-participation responsibility system and clarify the safety responsibilities of each subject. The university assumes the main responsibility for overall promoting the construction of the safety management system and ensuring the investment in safety management; the college assumes the direct management responsibility for implementing various safety management measures and strengthening the daily supervision of laboratories; the laboratory safety supervisor assumes the direct supervision responsibility for the daily safety management of the laboratory and supervising the standardized operation of teachers and students; teachers assume the safety supervision responsibility in the process of teaching and scientific research, responsible for guiding students to carry out experimental operations standardizedly and correcting unsafe behaviors in a timely manner; students assume the responsibility of self-protection, strictly abide by safety management systems and operating specifications, take the initiative to participate in safety training and emergency drills, and improve safety awareness and self-protection capabilities. Third, establish and improve the accountability mechanism. For subjects that fail to perform safety responsibilities, engage in irregular operations leading to safety accidents or major potential safety hazards, investigate their responsibilities in accordance with laws and regulations, and form a good atmosphere of "whoever is responsible must bear it, and whoever fails to fulfill their responsibilities must be held accountable".

4.2 System Standards and Specification System

The system standards and specification system is the foundation of the laboratory safety management system, providing clear behavioral guidelines and operational basis for safety management work. Its core contents include: First, improve the basic management system and formulate basic systems such as the "Measures for the Safety Management of Laboratories". Second, refine special management systems and formulate special management systems for different experimental scenarios. Third, formulate standard operating procedures (SOP) and standardize experimental operations in combination with the characteristics of different experiments. Fourth, establish a dynamic system update mechanism and revise and improve the system regularly. Fifth, strengthen the implementation of the system and supervision and inspection, and establish a regular supervision mechanism for the implementation of the system to ensure that the system is implemented in place.

4.3 Whole-Process Risk Control System

The whole-process risk control system is the core of the laboratory safety management system, aiming to reduce the probability of safety accidents. Its core contents include: (1) Risk identification mechanism: establish a systematic and comprehensive risk identification system, identify laboratory risk points by various methods, and establish a risk list. (2) Risk assessment mechanism: set up a professional team, adopt a combination of qualitative and quantitative assessment methods to assess risk points, determine risk levels, clarify prevention and control priorities, and form a report to provide a basis for formulating measures. (3) Risk prevention and control mechanism: formulate targeted measures for risk points of different levels. Strict control measures are taken for high-risk points, and conventional control measures are taken for medium and low-risk points. (4) Risk monitoring and update mechanism: establish a dynamic monitoring system, continuously monitor changes in risks, update the risk list and assessment report in a timely manner, and adjust prevention and control measures to ensure effectiveness.

4.4 Education and Training and Cultural Construction System

The education and training and cultural construction system is the soul of the laboratory safety management system, aiming to improve the safety awareness and literacy of teachers and students and cultivate a good laboratory safety culture. Its core contents include: (1) Build a hierarchical and classified education and training system, and carry out targeted training according to the safety needs of different

subjects and different disciplines and majors. (2) Innovate the form of education and training, adopt a diversified training method combining theoretical explanation and practical drill, online learning and offline training, case analysis and scenario simulation, so as to improve the interest and effectiveness of training. (3) Establish a strict training assessment mechanism, take safety training assessment as a necessary condition for teachers and students to enter the laboratory, and conduct regular retraining and assessment for teachers and students. (4) Strengthen the construction of safety culture and create a strong atmosphere of safety culture. Publicize laboratory safety knowledge and rules and regulations through various channels; carry out safety cultural activities to enhance the safety awareness and sense of responsibility of teachers and students; establish advanced safety models to play a demonstration and leading role; encourage teachers and students to take the initiative to participate in safety management and form a good atmosphere.

4.5 Intelligent Supervision and Emergency Response System

The intelligent supervision and emergency response system is the technical support of the laboratory safety management system, and its core contents include: (1) Build a unified intelligent laboratory safety supervision platform, integrate Internet of Things, big data, artificial intelligence, cloud computing and other technologies to realize real-time monitoring and early warning. The platform realizes the centralized management and sharing of data, providing data support for safety management decisions. (2) Improve the emergency response system, including the emergency plan system, emergency facility system, emergency drill system and emergency linkage system. Formulate detailed and operable emergency plans in combination with different types of safety accidents; equip sufficient emergency rescue materials in accordance with regulations and maintain and update them; carry out targeted emergency drills regularly to simulate real accident scenarios; establish a collaborative linkage mechanism with external emergency rescue institutions, sign cooperation agreements, and clarify the division of responsibilities. (3) Strengthen the construction of an intelligent management talent team, cultivate compound talents, and improve the intelligent management capabilities of existing safety management personnel[10].

5. Construction Path and Guarantee Measures of the University Laboratory Safety Management System

5.1 Construction Path

(1) Consolidate the foundation: Improve the organizational structure and responsibility system. Universities should set up a special laboratory safety management agency, improve the full-participation responsibility system, and establish and improve the accountability mechanism.

(2) Improve norms: Improve the system standards and specification system. Universities should combine their own disciplinary characteristics and laboratory actual conditions, establish a dynamic system update mechanism, and strengthen the supervision and inspection of system implementation.

(3) Core control: Build a whole-process risk control system. Universities should establish a systematic risk identification mechanism, set up a professional risk assessment team, formulate targeted prevention and control measures, and establish a dynamic risk monitoring and update mechanism.

(4) Improve literacy: Strengthen the education and training and cultural construction system. Universities should build a hierarchical and classified education and training system, innovate the form of education and training, establish a strict training assessment mechanism, and strengthen the construction of safety culture.

(5) Technological empowerment: Promote the construction of an intelligent supervision and emergency response system. Universities should increase investment in intelligent management, improve the emergency response system, and strengthen the construction of an intelligent management talent team.

5.2 Guarantee Measures

Formulate laboratory safety management policies and plans in combination with the actual situation of universities and national laws and regulations, and clarify the construction goals, tasks and steps. Strengthen communication and coordination with education, emergency management, fire protection and other departments to meet national requirements. Increase safety investment, establish a long-term

guarantee mechanism, and ensure the sustainable development of the safety management system. Strengthen the construction of a safety management talent team, improve professional quality and professional capabilities, build a training and assessment system, define post responsibilities, and establish an incentive mechanism. Combine internal supervision and external supervision mechanisms to achieve diversified supervision and promote safety work in depth and effectively. The college safety management group strengthens the daily supervision and inspection of laboratories and encourages teachers and students to participate in safety supervision. By taking the initiative to accept the supervision and inspection of relevant departments and safety rectification actions, continuously improve the safety management level, ensure better, more detailed and in-depth safety work, and provide a strong guarantee for the sustainable development of enterprises. Integrate safety connotation into teaching and scientific research links, making safety concepts a common and conscious habit of teachers and students.

6. Conclusion

The university laboratory safety management system is a key support to ensure the smooth development of laboratory teaching and scientific research activities and the safety of teachers and students' lives and property. Its construction is a systematic project covering multiple core elements such as organization, system, risk control, education and training, intelligent supervision, and emergency response. At present, although some progress has been made in the safety management of university laboratories in China, there are still problems such as unsound organizational structure, inadequate implementation of the responsibility system, imperfect system system, weak risk control capacity, insufficient education and training, poor emergency disposal capacity, and low level of intelligent management. Based on risk management theory and systems engineering theory, this paper puts forward the construction path of the university laboratory safety management system of "prevention first, systematic governance, clear responsibility, and collaborative efficiency". By improving the organizational structure and responsibility system, improving the system standards and specification system, building a whole-process risk control system, strengthening the education and training and cultural construction system, and promoting the intelligent supervision and emergency response system, the current problems existing in the safety management of university laboratories can be effectively solved, and the safety management level can be improved.

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