

A Preliminary Study on the Method of Refining Laboratory Safety Management in Engineering Universities

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Abstract: University laboratories play an important role in the development of schools and the country's scientific and technological progress, but while universities attach importance to the output of results, safety management is easily neglected. Most engineering universities have a wide variety of laboratories, which makes management difficult and there is an urgent need to explore refined management methods to protect laboratory safety. Based on the author's actual work, this paper explores the classification and grading management methods in order to provide reference for other universities' laboratory safety management.

Keywords: Engineering colleges and universities, Laboratory safety, Refined management, Classification and grading.

1. Introduction

The laboratory in higher education undertakes the task of teaching and scientific research, and is a necessary place for cultivating students' comprehensive quality [1]. In engineering schools, more than 95% of the output comes from laboratories, which have made indelible contributions to the cultivation of talents and the progress and renewal of science and technology in China. A safe and stable laboratory safety environment is a prerequisite for these achievements, and the laboratories of engineering colleges and universities involve high temperature, high pressure, radiation, dangerous gases, flammable and explosive hazardous chemicals, pathogenic microorganisms, etc. The risks of these laboratories are higher compared with those of liberal arts colleges and universities, so it is worthwhile for all teachers and students in colleges and universities to study and discuss how to do a good job in laboratory safety management.

2. The Current Situation of Laboratory Safety Management in Colleges and Universities

China's laboratory safety management in colleges and universities started later than others, and the General Office of the Ministry of Education issued the Notice on Further Strengthening the Safety Inspection of Teaching Laboratories in Colleges and Universities in 2019. As a result, the laboratory safety management in various colleges and universities officially appeared in the public view. All along university teachers and students, both top-level designers and front-line executors have not paid enough attention to laboratory safety. Only the scientific research benefits brought by the laboratory are they obsessed with, and they do not care about the environmental safety of the laboratory, which has also led to the frequent occurrence of laboratory safety accidents in universities in recent years, even costing teachers and students their lives. In December 2018, an explosion occurred in a laboratory of a university in Beijing, resulting in three students dead. In March 2021, an explosion

in a reactor at an institute of the Chinese Academy of Sciences killed one person. In July 2021, a doctoral student at a college in Zhongshan was rinsing a flask when it exploded and glass fragments punctured the arterial blood vessels of his arm. In October 2021, a laboratory at a university in Nanjing burst into flames, killing two people and injuring nine others. In April 2022, a laboratory at a university in Changsha burst into flames, resulting in injuries to a PhD student [2~3]. In the laboratory safety inspection in universities, author also found that more than 50% of teachers and students were more "disgusted and opposed" than "cooperative and supportive" to the inspection, and some teachers who have been engaged in scientific research for a long time said that "it has been like this for decades without any accident". The school is now strengthening its management to "target" them, and it sincerely does not want them to work in the laboratory, which is not beneficial to the development of the school.

3. Analysis of the Causes of The Current Situation

3.1. The assessment mechanism of universities disregards safety.

The assessment and evaluation mechanism of university laboratories is to see how many excellent talents have been trained, how many high level articles have been published, and how much economic value has been created for the university. The emphasis has always been on research output, and the "process" of achieving these results is not pursued. "Process" is not taken into account in any assessment or evaluation system. Therefore, laboratory safety, which is closely related to the "process", is not mentioned and not taken seriously.

3.2. Concealment of safety in university news reports.

As a result of China's unique national conditions, school news reports subconsciously minimize the impact of public opinion, and it is "customary" to reduce laboratory safety accident reports in official school reports, or to focus on

eliminating negative impacts rather than learning lessons and using accidents to carry out safety education. For many years, university accidents have been reported almost exclusively as major accidents with casualties, with minor accidents such as burns and hazardous chemical leaks not appearing in the news. Zhang Sen of Hebei University said, "Every safety accident is a teaching material, we have to change our thought, change the way, turn disadvantages into advantages, turn regrets into warnings, let the accident in its the most authentic state to educate more people, and play the value of education in the whole staff. [4] "According to the famous Heinrich's law, small hidden dangers and accidents are not taken seriously will eventually become a big disaster.

3.3. Colleges and universities' investment with neglecting safety.

Most university laboratory inputs are used to purchase advanced equipment or instruments, and very little for laboratory safety. It is because the investment in laboratory safety can not intuitively produce benefits, not to achieve immediate results, which is from long-term considerations, belongs to the preventive work. Besides, the amount of money invested varies from one university to another because of the different levels, and even some private universities do not invest anything in laboratory safety, including the most basic protective facilities, in order to reduce teaching costs.

3.4. Lack of safety awareness among teachers and students in colleges and universities.

The laboratory safety awareness of university laboratory is weak among teachers and students, and the lack of attention to laboratory safety is mainly performed by insufficient safety knowledge and poor safety habits [5]. Both undergraduate and postgraduate students do not pay enough attention to learning laboratory safety-related knowledge during their studies, and are not willing to participate in the laboratory safety education arranged by the university. Even if they do, they are forced to "go through the motions" and do not listen carefully.

3.5. The level of management staff in universities is difficult to solve safety problems.

Laboratory safety management departments in universities were established too late, and only in the past five years do dedicated institutions or sections set up one after another. The appointment of laboratory safety management staff is also temporary in the school. There is no professional counterpart of the talent pool for selection. Temporary selection of personnel without systematic training have half knowledge of laboratory safety management and limited management level. Even so, it is difficult for universities to provide sufficient management staff according to the number of management tasks.

4. Laboratory Safety Refinement Management Methods

In February 2023, in order to strengthen laboratory safety in colleges and universities and ensure the personal safety of teachers and students and campus stability, the Ministry of Education issued the Code for Laboratory Safety in Colleges and Universities [2023] No. 5, which aims to minimize laboratory safety accidents. For laboratories in engineering

universities, the risks are high, safety management is difficult and managers have a heavy workload. But they cannot be left unattended, and even greater efforts are needed to strengthen management and to manage more finely. Therefore, there is an urgent need for new methods to enhance laboratory safety management, reduce the work pressure of laboratory safety managers and reduce the potential risks of laboratory safety.

4.1. Refine the laboratory safety responsibility system and standardize the laboratory safety management system.

In accordance with the guiding principles of "the party and the government are responsible, one post is responsible for both, all together, and the failure to pursue responsibility", "management of industry must manage safety, management of business must manage safety", "who is in charge, who is responsible, who uses, who is responsible" "Build a four-level safety responsibility system with the university, the institute, the laboratory centre (research team, research institute) and the laboratory, decompose and clarify management responsibilities at all levels, and implement the laboratory safety management responsibilities to the post to the person. The university has also been able to improve its own risk resistance by building a system to improve the safety management mechanism of the laboratory. For example, Southwest Petroleum University has developed a management plan that is in line with the "oil-related and chemical-related" characteristics of the university's laboratories, and has adopted a point-by-point approach to expand the radiation of the laboratory safety management mechanism. Laboratory safety management is "clear in terms of authority and responsibility, standardized in terms of system, reasonable in terms of management and in place"

4.2. Carry out laboratory safety publicity and education activities to create a laboratory safety atmosphere.

Actively carry out various forms of laboratory safety publicity and education activities, including issuing "Laboratory Safety Knowledge Handbook" for new undergraduate and postgraduate students, designing cultural products that are popular among contemporary university students, and integrating safety cultural elements into students' lives. Organizing new students to take laboratory safety entrance examinations. Incorporating "Laboratory Safety Education" into the general knowledge module of talent training program. Organizing and carrying out laboratory safety month series of activities. Organizing various lectures on laboratory safety knowledge, etc. Through effective education and training on laboratory safety knowledge, participants in laboratory work can enhance their ability to master safety knowledge and deal with unexpected safety accidents, and create a good culture of laboratory safety.

4.3. Implementing laboratory classification and grading, with "special" and "general" management intertwined.

The classification of laboratories is mainly based on the types of dangerous sources existing in laboratories. According to the characteristics of laboratory teaching and research, laboratories in engineering colleges and universities are divided into four forms: chemical, mechanical and electrical, electronic and others. Then, according to the

different types of laboratory hazards and the differences in safety management, a graded management mechanism for laboratory safety risks is implemented. The "first class" laboratories are managed as "special" and the lower class laboratories are managed as "ordinary".

4.3.1. Laboratory classification

(1) Chemistry-based laboratories

Chemical laboratories refer to the use of chemical-based, more involved in chemical reactions, chemical reagents in the experimental premises. The hazards in such experiments are divided into two categories, one is the chemical hazards that may be brought about by flammable, explosive, toxic and corrosive chemicals, and the other is the physical hazards brought about by defects in equipment and facilities and protective defects. The management focus is on the safety management of hazardous sources such as controlled categories of hazardous chemicals, flammable and explosive chemicals, compressed gases and chemical waste.

(2) Electromechanical laboratories

Electromechanical laboratories refer to the use of mechanical and electrical equipment to carry out experiments, more involved in high-speed, high-voltage, high-power,

strong electricity, lasers and heating equipment and other experimental places. The main hazards of such laboratories and management focus on high temperature, high voltage, high power, high speed, high voltage, lasers, electromagnetic radiation devices and other special equipment safety management as well as special equipment and its employees related to the validity of the certificate audit.

(3) Electronic laboratories

Electronic laboratories refer to the use of small electronic equipment, mainly involving computers, instruments, circuit boards and other experimental places, including the establishment of various professional rooms. The main source of danger in these laboratories is the electrical energy on live conductors, such as electric shock, circuit short circuit, welding burns, etc.

(4) Other types of laboratories

In addition to the above three types of laboratories, the laboratory are classified as other types of laboratories, mainly including social sciences, arts, sports and office based laboratories or training rooms. The main sources of danger for the safety of equipment involving electricity. Its management focus on the standardization of electricity.

Table 1. Risk rating of chemical-based laboratories

No.	Item	Weighting	Evaluation Indicator	Score given
1	Teaching and research; Research direction	20	Whether the experiments carried out involve a high degree of risk, such as synthetic exotherm, pressure experiments, continuous heating, etc.	<ul style="list-style-type: none"> ● Involves synthetic exothermic experiments +5 ● Pressure experiments +10 ● experiments involving continuous heating +5
2	hazardous chemical; Hazardous wastes	40	Availability and use of explosives, flammable solids, acutely toxic or skin-corrosive/irritating chemicals, flammable and explosive chemicals in the laboratory; monthly production of hazardous waste in the laboratory	<ul style="list-style-type: none"> ● Presence of explosives +10 ● Presence of extremely flammable solids +10 ● Acute toxic or skin corrosive/irritating chemicals +5 ● With flammable and explosive chemicals >20kg +10 ● 1kg of waste per month, +1 ; 1kg < production ≤ 10kg, +3 ; >10kg, +5
3	Cylinder	10	Type and the number of cylinders, installation of gas monitoring and alarm devices	<ul style="list-style-type: none"> ● 1 to 3 cylinders, +2; 4 to 6 cylinders, +3 ; 7 or more cylinders, +4 ● here is a mix of different types of cylinders that could be dangerous (e.g. hydrogen and oxygen cylinders), +3 ● Laboratory has cylinders but no gas monitoring alarm device +3 ● 1 to 2 general pressure vessels, +2; 3 or more, +4 ● The number of pressure vessels under the control of the Quality Supervision Bureau: 1 to 2, +4; 3 or more, +6
4	Pressure vessel	10	The number of general pressure vessels, the number of pressure vessels under the control of the Quality Supervision Bureau	<ul style="list-style-type: none"> ● The number of oven and Muffle furnace: 1 to 2, +4; 3 or more, +6 分
5	Oven; Muffle furnace	6	The number of oven and Muffle furnace	<ul style="list-style-type: none"> ● Refrigerator without explosion-proof and has not been retrofitted with an explosion-proof design, +3 ● Refrigerator with storing dangerous chemicals +3
6	Refrigerator	6	Whether the refrigerator is explosion-proof or has been converted to meet explosion-proof requirements, whether hazardous chemicals are stored in the refrigerator	<ul style="list-style-type: none"> ● No safety procedures in place, +2; incomplete operating procedures, +1 ● Failure to implement safety access requirements, +3 ● Being inspected and notified more than 3 times in a year, +3
7	Safety Management Measures	8	Whether safety procedures are in place in the laboratory; whether a targeted safety training plan is in place and implemented; the number of inspections notified in a year	

4.3.2. Laboratory classification

Based on the risk assessment scores, chemical laboratories are classified into the following safety levels: those with scores ≥ 60 are chemical class I laboratories, with the most hazardous sources and the greatest risk; those with scores $30 \leq < 60$ are chemical class II laboratories, with a medium

number of hazardous sources and a medium risk level; those with scores < 30 are chemical class III laboratories, with a low number of hazardous sources and a low risk level.

(1) Level 1 safety risk laboratories

Laboratories using or storing hazardous chemicals and their waste; laboratories with toxic and flammable and explosive gas cylinders, large special equipment, single

heating equipment with a power exceeding 10Kw or single laboratory ($\leq 75\text{m}^2$) with a total power of heating equipment exceeding 15Kw and high pressure vessels with a pressure level greater than 10MPa; laboratories using highly toxic and highly toxic drugs. In addition, the "Risk Rating Scale for Chemical Laboratories" has been developed, see Table 1, for laboratories with a comprehensive evaluation of Level 1 safety risk scores.

(2) Level 2 safety risk laboratories

Chemical laboratories with reference to the "Chemical Risk Rating Scale" comprehensive evaluation to achieve a Level 2 safety risk score; electromechanical and electronic laboratories involving one of the following conditions are directly designated as Level 2 safety risk laboratories: the use of high-powered heating equipment such as muffle furnaces, electric resistance furnaces, the use of high-speed equipment for machining, pressure vessels, all-weather non-stop equipment and intermittent power supplies, large instrumentation, high-voltage equipment (above 10kV), laser equipment and strong magnetic equipment.

(3) Level 3 safety risk laboratories

Chemical laboratories with reference to the "Chemical Risk Rating Scale" comprehensive evaluation of the safety risk score of Level 3 laboratories; electromechanical and electronic laboratories are directly designated as Level 3 safety risk laboratories if they involve one of the following: instrumentation, mechanical equipment, strong electrical equipment and power tools.

(4) Level 4 safety risk laboratories

Computer rooms, speech rooms and office-based laboratories and training rooms for social sciences, arts, sports and related disciplines.

4.3.3. Different management approaches for different classes and levels

(1) Chemical Class I Laboratories

Laboratories must carry out their own hazard source identification, formulate preventive measures and emergency plans for different hazard sources, improve the relevant safety management system of the laboratory, and report to the college and the school's categorized management department for the record. laboratories must formulate safety training contents and plans in line with the characteristics of the laboratory, and designate special personnel to conduct safety education for relevant personnel on a regular basis. In addition to passing the safety access examination organized by the subtotal management, the personnel involved must also undergo professional training in the laboratory to which they belong, and the relevant supporting materials for the training process and results and the signed safety undertaking must be kept for inspection in each laboratory. For the operation and management of special instruments and equipment with risks, detailed use and operation procedures must be formulated and posted, and a dedicated person in the laboratory must be designated to manage them. Students cannot enter the laboratory alone to carry out experiments. There must be a tutor on site to guide them, and they must be on duty throughout the experiment. The laboratory must conduct self-inspection every day, the college (unit) must routinely inspect it every week and fill in the records carefully. The school's professional management department will inspect the laboratory at least once a week.

(2) Secondary laboratories of chemistry and electromechanics

Laboratories must identify their own hazards, formulate

precautionary measures and emergency plans for different hazards, improve the relevant safety management system of the laboratories and report to the college for record. Laboratories must formulate safety training contents and plans in line with the characteristics of the laboratories and designate special personnel to conduct safety education for relevant personnel on a regular basis. In addition to passing the safety entrance examination organized by the Laboratory and Equipment Management Office, the personnel involved must also undergo professional training in the laboratory to which they belong, and the relevant supporting materials of the training process and results and the safety commitment letter signed must be kept in each laboratory for inspection. The laboratory should conduct daily safety self-inspection and fill in the records carefully. The college should inspect the laboratory at least once every fortnight. The school's professional management department should inspect the laboratory at least once a month.

(3) Level 3 laboratories of chemistry, electromechanics and electronics

Laboratories should identify the sources of danger. If necessary, formulate precautionary measures and emergency plans for different sources of danger, and formulate a relevant safety management system for the laboratory. The laboratory must be formulated a safety training plan that meets the characteristics of that laboratory. People in it should be conducted safety education and training for relevant personnel on a regular basis. The laboratory should be conducted daily safety self-inspection and filled in records carefully. The college should inspect the laboratory at least once a month. The school professional management should inspect the laboratory at least once a quarter of a year.

5. Conclusion

The variety and number of risk sources within laboratories in engineering colleges and universities make it difficult to take into account every laboratory. The fine-grained approach to laboratory management may seem to require a lot of effort to collect and clear up the data, but in fact it is a "A beard well lathered is half shaved". We can approach that make it allow for "less control" of laboratories with low risk levels, and make management focus towards "high-risk" laboratories. In the long term, it not only saves human and financial resources, but also reduces hidden dangers in university laboratories with half the effort, which is worth learning from other engineering universities.

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