

An Evaluation of Safety and Health Level in Chemical Laboratories

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Abstract : In recent days, the accidents have happened at experimental laboratories in universities or institutes. In order to improve safety assurance of workers in laboratories, it is required to carry out systematic study concerned with evaluation of safety and health level. The safety and health inspection checklists were developed and conducted the case study. The case study was carried out laboratory safety inspection with 5 inspectors by the checklists to become aware of safety and health level. From the evaluation results of the inspection, we could be made quantification of laboratory through evaluation of safety and health level in laboratory. It was found that was recognized present states of the laboratory and established a plan for improvements in laboratory safety facilities from the case study. The safety inspection checklists can be used as basic data to establish evaluation criteria of safety and health level.

Keywords: accident, evaluation, laboratories, laboratory safety inspection, safety level

1. Introduction

There are potential risk factors of various types in laboratories with increase of research works and educational activities. Concerning laboratory risk factors, there are mechanical, physical hazard as well as chemical and biological hazard, and there occurs loss of death or injury in laboratory including mainly fire, explosion and toxication from time to time [1].

In recent days, the accidents have happened at experimental laboratory in universities in Korea. In September 1999, explosions of aluminum powder occurred in Engineering laboratory of Seoul National University and injured 3 fatalities [3]. In July 2003, in Aeronautics and Space laboratory of KAIST injured 1 fatality and 1 burned person by explosion during a hydrogen peroxide reaction experiment [4]. These are significant reminders of the importance of laboratory safety in universities. Moreover, the universities do not open to the public the condition of their laboratory safety except under special conditions like a serious accident or a detailed safety diagnosis. The government agency and the administrative authority have not rendered strict administrative services in connection with laboratory researchers and workers. In Korea, there are some reports in relation to

studies on policies concerning laboratory safety and the guidelines etc. that published on certain literatures [1, 2, 5]. However, there is lack of systematic and consistent research efforts concerned about laboratory safety guidelines, safety manual, and safety level evaluation like advanced countries [6-8]. In order to improve safety assurance in laboratories, it is required to carry out systematic research works concerned with evaluation of risk level of laboratory health and safety [9-10].

In this study, In order to improve and quantify the laboratory safety level, it was developed the safety inspection checklists and conducted the case study through the checklists in college laboratory. The final objective of this work was to prevent accident from laboratory through effective safety management by presenting a quantitative method of health and safety level developing safety inspection checklist for college laboratory.

2. Safety Inspection Checklists

For evaluation of laboratory safety level, first of all, we need to recognize present state of laboratory health and safety, and then to evaluate laboratory risk level. For this, it tried to confirm laboratory safety level through fact-finding survey developing a inspection checklist for the situation of the college laboratory. And, it also was to elicit a safety management method

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perceiving status of risk that is latent in laboratory.

In this work, in order to evaluate college laboratory safety level, inspection checklist for laboratory safety developed to be fit for our situation referring to the inspection list proposed by Occupational Safety and Health Administration (OSHA) of the United States [7]. The checklist for laboratory safety consists of 8 items, including laboratory work practice, laboratory management, safety sign, and so on. It was developed 3 criteria for each question on checklist, i.e. "poor," "good" and "excellent," and for the rest of items, we designed it in order that the inspector can check it on nearer side, and then evaluate it by the 5-point scale. With summary of main contents and evaluation items on checklist, this provides in Table 1.

3. Case Study

3.1 Inspection and Analysis Method

In this study, it was selected 32 laboratories in Chemical and Biological Engineering Department of Seoul National University in order to evaluate laboratory safety level surveying the present state of laboratory safety. Characteristics of these laboratories were that

they mostly used various chemicals and gases, etc. and either graduate school students or researchers worked at a divided in the laboratory.

Using identical checklist developed in this research work, 5 inspectors in safety environment field inspected the state of each laboratory and each checked on the same item. Inspection team was composed of inspectors from several specialized skill areas; 2 from chemical engineer, 2 from environment engineer, and one from radiologist. Particularly, 2 inspectors participated in this research work were staffs of the Institute of Environmental Protection and Safety of Seoul National University. To evaluate the present state of laboratory safety, time consumed for fact-finding survey according to one laboratory was about 20 to 30 minutes, and in order to get more accurate information, if required, inspectors interviewed the graduate students and researchers who worked at the subject laboratory.

Concerning analysis method, check lists for laboratory safety in order to evaluate laboratory safety level gave 5-point scale, and each inspector evaluated risk level with regard to each item. When performing inspection, if it was poor (less than 2 points), each inspector then wrote down the causes or reasons. In order to evaluate

Table 1. Summary of inspection checklist for laboratory safety level

Evaluation Items	Principle contents	Items number
Laboratory work practices	<ul style="list-style-type: none"> o No smoking, food and beverages rule o Pipette means and designated areas of hazardous substance o Containment after work or spill, syringes management etc. 	7
General laboratory keeping	<ul style="list-style-type: none"> o Storage or arrangement conditions of stuff/materials o Conditions of electric wires, cords and earthing o Conditions of exit pathway and working surface 	9
Chemicals storage	<ul style="list-style-type: none"> o Storage of chemicals and segregation of ignition source o Storage/keeping of unused or outdated chemicals o Safety cabinets available and safety carrier for chemicals 	6
Flammable liquid storage and handling	<ul style="list-style-type: none"> o Storage conditions of flammable liquid and segregation o Presence of safety cans labeled 	8
Compressed gas cylinders	<ul style="list-style-type: none"> o Chains and caps installation of gas cylinders o Storage conditions of gas cylinders o Conditions and label indication of gas lines or piping 	9
General facility and laboratory characteristics	<ul style="list-style-type: none"> o Steady or resistant of laboratory furniture o Record of all personnel entering and exiting in limited access areas 	5
Means of Egress/Emergency Evacuation	<ul style="list-style-type: none"> o Proper indications of emergency exit or evacuation o Installation or conditions of fire doors and fire alarms o Telephone labeled with emergency number 	5
Safety equipment	<ul style="list-style-type: none"> o Installation or conditions of safety showers and eye washers o Working conditions of fire detection devices, smoke alarms, and lighted exit signs o First-aid kits, spill containment available 	8

laboratory safety level, it was edited each item concerned with the state of laboratories that investigated by 5 inspectors on identical checklist items into worksheet file, and analyzed by EXEL statistic program. By summing points up of each item according to inspector and by averaging it, we quantified the results by converting it on the basis of 500 points, full marks.

3.2 Safety Level according to Evaluation Item

Work practices of laboratory area

The work practice in laboratory marked 269 points out of full marks of 500, it revealed insufficient safety level. There were many laboratories where researchers took food or beverages, etc. within the facility, or stored it within the laboratory. An example of keeping food and beverage in laboratory shows just one case of among the pictures in Figure 1. During of taking food or beverages within the laboratory, contaminants may be absorbed into our body, and in long run, it may affect the our health. In laboratory work practices, inspectors found traces in that graduate students used coffee pot and took beverages, etc., also inspectors found that beverages were kept in refrigerator together with the test instruments or chemicals.

Laboratory housekeeping and general facilities

In laboratory housekeeping, safety level marked 180 points, and the results from inspection revealed that safety level in the laboratory was insufficient. It requires urgent improvements. Particularly, problems were found in the state and manner of keeping and arranging relevant articles and materials in the laboratory, confused wiring that twisted together into a jumbled mass, and state of earthing, and no clear egress, or emergency exit.

Storage of chemicals and flammable liquid

Examples of storage of chemical and flammable liq-



Fig. 1. Food and beverage in laboratory.



Fig. 2. An example of bulk chemicals storage.

uid in laboratory the describe Figures 2 As shown in figures, corrosive and flammable substances were stored beyond the height of eye sight, or hazardous materials that normally used in experiment were kept as in bulk state. In the event of a chemical spill or fire, incompatible chemicals that are stored in close proximity can mix and create fires, explosion and toxic fumes.

Storage and handling of compressed gas cylinders

Safety level of storage and handling of compressed gas cylinders in laboratory marked 256 points, it revealed insufficient safety situation. Combustion supporting gas (oxygen) and combustible gas are kept mixed; it is a great deal of danger of fire or explosion when they are leaked. Inspectors found out that electrical plug and wall socket was not isolated from flammable gases, they can make dangers of fire or explosion by spark. In addition, No gas detector or alarm for combustible gases in the gas cabinet was in place, and the cylinders caps were not placed. Gas cylinders must be stored upright and properly chained. Caps should be placed on unused cylinders. Also, Gas cylinders must not block access to work areas or points of egress.

Emergency evacuation and safety equipments

Safety level of emergency evacuation was rated at



Fig. 3. Mixed storage of compressed gas cylinders in the gas cabinet.



Fig. 4. Laboratory equipments and material near the exit door.

215 points, this point indicates poor state of safety level. Figure 4 shows an example of safety management practices focusing on a picture of storing equipments and articles in front of the exit door. Most of laboratories heaped pile of test equipments, or instruments, or other materials or articles in front of emergence exit door. Also, there were no signs for evacuation/emergency escape, or signs were not put on a proper place conspicuously. It can be difficult to make a quick evacuation in time of emergency. Therefore, it is required to secure a pathway for emergency evacuation. While on the other, the safety level of safety equipments was good marks with 313 points. Concerning safety equipments, the signs of safety showers and eye washers were not clearly labeled, and there were safety shower in each floor.

Animal handling/biohazards

Animal handling and biohazards marked 220 points out of 500, full marks, and the results from inspections revealed that health level was insufficient. When biological test was performing in the lab, blocking or limiting approach, and access warning sign, etc. were not properly done or displayed, and most of laboratory using microorganism didn't have any procedures relating to storage and disposal of microorganism. In some laboratories, DNA and bacteria were discarded to waste basket without sterilization, besides they didn't keep records concerned with disposals.

Personal protective equipment

Right use of personal protective equipment and health level marked 170 point, revealing a little lower level, and it requires improving urgently. Personal protective equipment that most frequently used in laboratory are lab gown, protective coat, dust proof mask, gas mask, and safety glove, safety goggle and so on, and inspectors found many cases of tests in which researchers

engaged in test without wearing laboratory gown or protective coat, and there were no separate place to keep gowns in the premises so that it was placed anywhere within the facilities and some lab gowns were found in a state of not having been cleaned for a long time. Most of researchers kept gas mask, dust proof mask, and safety goggle, etc. privately and used so, and particularly, in case of gas mask, it was often found that its filter were kept having been exposed amid air of laboratory.

Hazard communication

Health level of risk information delivery part of chemical substance marked 170 points, revealing a little lower level. Warning marks were put on chemical substances or vessels thereof according to Material Safety Data Sheet (MSDS) comparatively in a good manner; however, because of bad state of keeping chemicals, there were some occasion of being unable to confirm expiration date. There were no places to display MSDS on chemical substances that used, and it was hard to find a case to have made a list and kept it properly and, in case of computer network, even though researchers may search information through internet, there was no set up for "short cut key" or it was found that in some terminals, relevant services were closed.

Waste handling and disposal

Health level of waste handling and disposal marked 171 points, revealing a little lower level. Since wastes occurred in laboratory are so varied that it should be handled in a way of helping treatment or disposal by discharging it separately as possible.

Ventilation

Point of health level of ventilation part was 143, which was a very lower mark. Except whole ventilation according to window and door, etc. or natural ventilation facilities, local exhaust equipments were fume hood, mounting box type hood, and exterior type hood, and so on. In case of fume hood, there appeared conspicuous differences of control velocity according to position located between floors in laboratory, and depending upon degree of opening, it showed significant difference of control velocity.

Labeling and posting

Health level of labeling and posting area marked a very lower point, 130. It was found that there were placed having no labeling on storing or handling vessel concerned with substances, and that there were some

cases of being unable to identify markings, although there were labeling or posting. State of posting signs, including safety and health mark and standard work safety rule, etc. regarding test facilities or equipments were insufficient.

4. Conclusions and Further Study

In order to improve and quantify the laboratory safety level in academia, the safety inspection checklists developed and conducted the case study through that in college laboratory. The case study was performed present state survey having selected 32 laboratories at school of chemical and biological engineering in Seoul National University. And also, the case study was carried out laboratory safety inspection with 5 inspectors by safety checklists to become aware of safety level. It was found that was recognized present states of the laboratory and established a plan for improvements in laboratory safety facilities from the case study. The safety level in the college laboratory was poor with 238 points.

In addition, by evaluating health level according to each laboratory or college, it may be used as basic reference material to plan an investment in health and hygiene facilities in laboratory as well as criteria of evaluation for approval of safety and health level in laboratory. It is thought that establishment of a systematic and integrated health management system in laboratory through health evaluation will be possible.

Based on safety levels that confirmed by this study, the safety inspection checklists can be used as basic data to establish evaluation criteria of laboratory safety level, and it could be made quantification of laboratory through evaluation of laboratory

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